A COMPARISON OF EARLY VERSUS LATE WEANING FOR THE PRODUCTION OF SLAUGHTER STEERS IN FLORIDA

BY

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A DISSERTATION PRESENTED TO THE GRADUATE SCHOOL OF
THE UNIVERSITY OF FLORIDA
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR
THE DEGREE OF DOCTOR OF PHILOSOPHY

UNIVERSITY OF FLORIDA

1986

ACKNOWLEDGEMENTS

The author wishes to express her deepest gratitude to Dr. D. D. Hargrove, chairman of her committee, for his guidance, supervision and assistance throughout her graduate studies and in preparation of this dissertation. Sincere appreciation is extended also to the other members of the supervisory committee, Dr. T. A. Olson, Dr. J. R. Simpson, Dr. R. L. West, and Mr. D. L. Wakeman, for assistance, encouragement, and friendly advice.

The author would like to extend special thanks to her fellow graduate students who helped her in the collection of experimental data. Those students include James Drouillard, Melanie Bouman Bentana, Carlos Fontes, Luiz Lopes, Sornthep Tumwasorn, Roberto Betancourt, Barbara Robinson, and Sergio Cesar.

Appreciation is expressed to Paul Dixon and the Beef Research Unit crew for their help in collecting data used in this manuscript and for their friendship. The writer wishes to thank Larry Eubanks and the crew at the University Meats Laboratory for their help in collecting carcass data.

Special acknowledgement is expressed to the Organization of American States (OAS) for sponsoring part of the author's Ph.D. program at the University of Florida.

Deepest gratitude and appreciation go to the author's parents, sisters, brothers, and friends for their encouragement and valuable support throughout the course of this study.

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Abstract of Dissertation Presented to the Graduate
School of the University of Florida in Partial Fulfillment
of the Requirements for the Degree of Doctor of Philosophy

A COMPARISON OF EARLY VERSUS LATE WEANING FOR THE PRODUCTION OF SLAUGHTER STEERS IN FLORIDA

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May, 1986

Chairman: D. D. Hargrove
Major Department: Animal Science

One hundred and twenty-five steers sired by Brahman or Romana Red bulls and out of Angus and Brown Swiss x Angus (SA) F_1 and F_2 crossbred dams were utilized in a two-year experiment to study effects of weaning at 7 versus 9 months of age on preweaning and postweaning performance and carcass characteristics.

Steers were started on creep feed at an average age of 5 months and were switched from the creep ration to a feedlot ration when the 7-month group was weaned. Average daily consumption of creep feed by all steers from 5 to 7 months of age was 3.1 kg. From 7 to 9 months of age, the weaned calves consumed an average of 8.3 kg of the feedlot ration per day, while the steers remaining with their dams and receiving the ration as creep feed consumed an average of 5.1 kg per day. Average daily gain from 7 to 9 months of age and 265-day weight were not significantly different for the two groups. Steers from SA crossbred dams had heavier (P<.07) 265-day weights than those from Angus dams, and Brahman-sired steers tended (P<.15) to be heavier than those sired by Romana Red bulls. Dams whose calves were weaned at 7 months of age gained 16 kg from the 7- to 9-month weaning date, while those that nursed their calves for two more months lost 1.0 kg and .7 units of a condition score (P<.01). Weaning age treatment significantly affected average daily gain from 9 months of age to slaughter and from 7 months of age to slaughter. Brahman-sired steers outgained the Romana Red-sired steers and steers from SA crossbred dams outgained those from Angus dams in both periods. Late-weaned steers were more efficient than early-weaned steers. Carcasses from early-weaned steers had lower shear force values (P<.008) and more estimated separable fat (P<.096) than those from late-weaned steers. Brahman-sired steers were 29 kg heavier (P<.003) at slaughter, had a higher (P<.02) average weight per day of age at slaughter, and had a higher quality grade than the Romana Red-sired steers. Steers from SA crossbred dams were 79 kg heavier (P<.0001) at slaughter, 33 days older (P<.0001), and dressed about 1% higher (P<.04) than those from Angus dams.

INTRODUCTION

Florida has a large commercial beef cow-calf industry and is the ninth ranking state in the nation in number of brood cows. Since Florida produces little of the grains used for feeding cattle, a high percentage of calves born in the state are shipped out-of-state for growing, finishing, slaughter, and processing, and are then shipped back into the state in the forms of boxed and carcass beef. Florida annually imports more than 80% of the fed beef consumed in the state. By feeding and finishing its own cattle, Florida would increase state revenue and create more jobs.

It is the normal practice in Florida to wean calves in the summer and fall at an average age of about 7 to 8 months. This is when forage growth is still at its peak. Because of Florida's wet winters, it is difficult to preserve this surplus forage for winter feeding. One way of utilizing this surplus forage would be to wean calves at an older age, thus utilizing some of the forage that might otherwise go to waste.

There is a need for efficient systems of finishing cattle in Florida. By producing heavyweight calves at weaning, Florida producers could send these calves directly to the feedlot and finish them in a short feeding period.

The combination of appropriate breeding and management techniques, such as creep feeding, growth implants, and late weaning, should result in the production of heavyweight weaning calves ready for placement in feedlots.

The following study is one segment of a project designed to develop efficient systems for the production of slaughter steers in Florida. The objectives of this study were to determine the effects of breed type, creep feeding, and late weaning on pre- and post-weaning performance and carcass characteristics, of steers and on weight, condition, and reproduction of their dams.

LITERATURE REVIEW

Factors Affecting Preweaning Performance

Breed of Sire

Numerous studies have shown significant breed of sire effects on most preweaning traits. Gregory et al. (1979) found Brahman-sired crossbred calves had significantly higher 200-day weights than those sired by Hereford, Angus, Sahiwal, Pinzgauer, and Tarentaise bulls. Crockett et al. (1981) also reported significant breed of sire effects on preweaning performance. They compared calves sired by Beefmaster, Brahman, Brangus, Limousin, Maine-Anjou, and Simmental bulls and out of Angus, Brangus, and Hereford cows. Calves sired by Brahman and Maine-Anjou bulls had the heaviest birth and 205-day weights. Barlow and O'Neill (1978) mated Simmental, Friesian, Brahman, and Hereford bulls to Hereford cows. They found that all crossbred calves grew faster to weaning than straightbred Hereford calves. They also reported that the preweaning performance of calves sired by Simmental and Brahman bulls was comparable and was superior to that of the other crosses. Average daily gains from birth to weaning were .729, .725, .719, and .680 kg, respectively, for the Simmental, Brahman, and Friesian crossbreds and the straightbred Herefords, respectively. The advantages of the crossbreds over the straightbred Hereford calves in weaning weight were 12.4 kg for the Brahman x Hereford, 15.1 kg for the Simmental x Hereford, and 16.3 kg for the Friesian x Hereford crossbred calves.

Peacock et al. (1978) reported significant breed of sire effects for weaning weight and condition score. However, in contrast to the studies previously mentioned, this study showed no superiority of Brahman-sired calves as compared to calves sired by Angus and Charolais bulls. Charolais-sired calves were heavier at weaning (223 kg) than those sired by Angus and Brahman bulls (199 and 195 kg, respectively). Similar results were reported by Kincaid (1962), who observed a clear superiority in weaning traits of British x Brahman crossbred calves as compared to straightbreds. Calves sired by Angus bulls had the highest average condition score followed by those sired by Charolais and Brahman bulls. Significant breed of sire by breed of dam interactions for condition score were observed. Angus x Brahman calves had a condition score of 10.2 compared to 9.8 for Brahman x Angus calves. Data from Pahnish et al. (1969) supported these findings.

Crockett et al. (1978) conducted a study comparing straightbred Angus, Brahman, and Hereford calves and all possible two breed-of-sire rotational crosses. They reported that calves sired by Brahman bulls were heavier at weaning than those from Angus bulls, when both bull breeds were mated to Hereford cows. There were no significant differences in weaning weight among the straightbred groups. Turner and McDonald (1969) found that the growth rate and weaning weight of calves sired by Brahman and Hereford bulls were comparable, but exceeded those of calves sired by Angus bulls. Calves sired by Charolais bulls outperformed those sired by Brahman, Hereford, and Angus bulls.

In another experiment, it was reported that calves sired by Brahman bulls tended to bring out more of the production potential of F_1 Brahman-Shorthorn cows. Results from Peacock et al. (1973) showed that, when mated to F_1 Brahman-Shorthorn cows, Brahman bulls produced calves with heavier 205-day and weaning weights, and increased production per cow. Calves sired by Shorthorn bulls, on the other hand, carried more condition at weaning than those sired by Brahmans. Reynolds et al. (1982) also showed that calves sired by Angus bulls carried more condition at weaning than those sired by Brahman bulls. When comparing the Brahman to the Romana Red, a different zebu type, Hargrove et al. (1983a) found that Brahman-sired calves were heavier at 150 and 205 days of age and gained more rapidly then those sired by Romana Red. Bailey (1981) compared preweaning performance of calves sired by Brahman, Hereford, Red Poll, and Angus bulls. Brahman-sired calves exceeded (P<.01) progeny of Hereford, Red Poll, and Angus bulls for preweaning performance, even though the Brahman-sired calves were weaned at significantly (P<.01) younger ages. This breed of sire variation in weaning age may be attributed, in part, to differences in length of gestation period. The gestation period for Brahman-sired crosses averaged 7.7 days longer (P<.01) than that for Angus x Hereford crosses (Gregory et al., 1979).

Breed of Dam

Preweaning calf performance is highly correlated with the dam's milk producing ability; therefore, significant breed of dam effects are inevitable when breeds of different milk producing potentials are compared. Many studies have shown differences due to breed of dam for traits such as calf weaning weight, condition score, and frame score. Gaines et al. (1966) reported that calves from Hereford dams weighed less at weaning and had lower feeder grades than calves from Angus and Shorthorn dams. Comparisons of all possible crosses among these three breeds showed that calves from Hereford dams were 23 kg lighter at weaning than calves from Angus and Shorthorn dams. This difference probably was due to the superior milk producing ability of the Angus and Shorthorn dams.

Peacock et al. (1978) conducted a crossbreeding study in which Angus, Brahman, and Charolais cattle were straightbred and reciprocally crossed in all possible two-breed combinations. Breed of dam effects were significant for all preweaning traits, except for condition score of calves. Angus dams weaned older calves than did Charolais and Brahman dams. Weaning and 205-day calf weights were heaviest for Charolais dams, with Brahman dams next, and Angus dams the lowest. Significant breed of sire x breed of dam interactions occurred for condition score, 205-day weight, and weaning weight of calves. Crockett et al. (1981) found that crossbred calves from Brangus dams were significantly ($P<.01$) heavier at 205-days of age than those from Angus and Hereford dams. In an earlier study (Crockett et al., 1978), no difference in calf weaning weight due to breed of dam was found, when comparing straightbred Angus, Hereford, and Brahman dams.

Since preweaning performance depends, in part, on milk production of the dam, researchers have studied the effect, on preweaning traits of calves, of incorporating dairy breeding into beef herds. Andrade (1980) conducted a study in Florida using two-year-old Angus, Brown Swiss, and F_1 Angus x Brown Swiss reciprocal crossbred heifers. He reported that calves from Angus heifers had lower ($P<.01$) 205-day weights than calves from the Brown Swiss and the F_1 crossbred heifers. Using the same breed of dam, Hargrove et al. (1983a) reported that F_1 Angus x Brown Swiss cows produced calves that had a higher average daily gain and were heavier at 150 and 205 days of age than calves produced by Angus cows. Similar results were reported by Olson et al. (1985), who also compared performance of Angus, Brown Swiss, and Angus x Brown Swiss reciprocal F_1 dams when mated to the same three breed groups of sires. Breed group of dam and sire significantly influenced birth weight, preweaning daily gain, weaning weight, 205-day weight, condition score, and frame size. Calves out of Brown Swiss dams were heaviest at birth and weaning followed by Angus x Brown Swiss and Angus dams.

Pahnish et al. (1969) showed that crossbred progeny of Brown Swiss dams had heavier weights and higher average daily gains than crossbred calves nursing beef type dams. In a study involving Angus x Hereford, Charolais x Hereford, Hereford x Hereford, and Brown Swiss x Hereford cows mated to Angus and Charolais bulls, the Brown Swiss x Hereford dams weaned 34.6 kg more calf per cow exposed than did the Angus x Hereford and Charolais x Hereford dams (Nelson et al., 1982). The authors also reported that dairy x beef crossbred dams weaned 47.6 kg more calf per cow exposed (P<.01) than the average beef x beef crossbred dams. Belcher and Frahm (1979) also examined the productivity of various beef x beef and dairy x beef crossbred cows and their calves. The crossbred females were produced by mating Hereford, Angus, Simmental, Brown Swiss, and Jersey bulls to Hereford and Angus cows. These crossbred females were mated to Red Poll and Shorthorn bulls. The heaviest calves at weaning were produced by Brown Swiss x Angus cows (203 kg) and the lightest by Hereford x Angus cows (168 kg). The superiority of calves out of dairy x beef crosses over beef crosses is not surprising, since incorporating dairy breeding will increase milk production. Average daily milk production was found to be 8.3, 6.8, and 5.3 kg, respectively, for Brown Swiss, F_1 Brown Swiss x Angus, and Angus cows (Euclides et al., 1983).

In a study comparing Red Poll, Charolais, Hereford, and Angus straightbred and crossbred dams, Bailey (1981) again demonstrated the importance of maternal influence on preweaning growth. Red Poll and Charolais crossbred dams weaned heavier ($P<.01$) calves than Hereford dams, and progeny of Angus dams also surpassed those of Hereford dams at weaning.

Weaning Management

Information collected on the preweaning growth rate of Angus, Hereford, and Shorthorn calves in the temperate region of the United States showed that gains decreased rapidly after 240 days of age (Marlowe and Gaines, 1958). Johnson and Dinkel (1951) found that growth rate of Hereford calves on range was almost linear from birth to 155 days of age, and that from 155 days to 225 days of age the growth rate increased at a decreasing rate. Calf growth records from crossbreeding studies conducted by Crockett (1977) at Belle Glade, Florida, showed that nursing calves with Brahman breeding performed much better than Angus or Hereford calves from 7 to 9 months of age. Brahman and Brahman crossbred calves gained .75 kg per day, while daily gains by Angus and Hereford calves were .41 and .45 kg, respectively.

Pate et al. (1985) compared the performance of Brangus cows and calves, when calves were weaned at average ages of 8.5 months and 10.5 months. Cows nursing calves for 10.5 months gained 31 pounds less than the cows whose calves were weaned at 8.5 months. However, the cows whose calves were weaned at 10.5 months of age tended to lose less weight, or gain more, during other periods of the year. This resulted in a similar annual weight change for both groups of cows. Calves left with cows until they were 10.5 months old gained an additional 37 kg from 8.5 to 10.5 months of age, and had a 32 kg heavier weaning weight than calves weaned at 8.5 months of age. Weaning calves at 10.5 months of age increased calf production (calf weaning rate x calf weaning weight) by 28 kg for the average cow in the breeding herd.

Chestnutt (1982) compared calf and cow performance when calves were weaned at 7 and 10 months of age. The calves were out of Aberdeen Angus x British Friesian crossbred cows mated to Charolais bulls. Calves weaned at 7 months of age (March) weighed 30.2 kg less than those weaned at 9 months of age (July). This difference narrowed to 26.5 kg by August. When measured in August, cows that weaned their calves in July weighed 22.3 kg less than those that weaned their calves in March. The author concluded that late weaning might be preferable, producing heavier calves, provided that cow weights can be restored on pasture.

Powell (1975), on the other hand, found little extra gain as a result of weaning two months later.

Factors Affecting Calf Postweaning Performance

Breed of Sire

In a study designed to evaluate the differences in postweaning growth of three-breed crossbred steers, Young et al. (1978) reported that the effect for breed of sire of calf was highly significant for all growth traits studied. For postweaning growth to 452 days of age, Devon-sired steers gained the least ($P<.05$), Holstein-sired steers gained the most, and steers sired by Hereford, Angus, and Brahman bulls were intermediate and similar. Due to their large weaning weights, steers sired by Brahman bulls were heavier ($P<.05$) at 425 days than those sired by all other breeds except the Holstein. Although Brahman-sired calves were 20 kg heavier at 200 days of age than those sired by Holstein, the higher postweaning gain exhibited by the Holstein-sired calves reduced the difference so that it was not significant at the end of the feeding period. Similar results were reported by Cundiff et al. (1984). They reported that Brahman-sired crossbred calves were significantly heavier at weaning than all other breed groups, but this advantage was lost during the postweaning period. Cartwright et al. (1964) also reported that Brahman-sired calves grew slower postweaning than did

Angus-sired and Hereford-sired calves. Crockett et al. (1979), on the other hand, found Brahman-sired steers to be heaviest at both the beginning and end of the feedlot phase, when compared to steers sired by Brangus, Limousin, Beefmaster, and Simmental bulls.

Cundiff et al. (1984) reported that, when breeds of varying types were fed to a constant fat trim, Brown Swiss-sired calves were similar in feed efficiency to those sired by bulls of European (Continental) beef breeds, and were less efficient than steers sired by bulls of the British beef breeds. They reported that larger framed, later maturing steers (such as Brown Swiss) required longer feeding periods to reach the designated fat thickness endpoint. This resulted in the Brown Swiss using more feed for body maintenance and less for growth than the smaller steers sired by British beef bulls. Garret (1971) concluded that the difference in feed efficiency between dairy and beef steers seemed to be due to the more efficient fat deposition (energy storage) of beef steers and the higher maintenance requirement per unit of body weight of the dairy-type steers.

Significant interactions were found between breed of sire and breed of dam for birth weight, preweaning average daily gain, adjusted 205-day weight, yearling weight, adjusted 365-day weight, and weight per day of age (Massey and Benyshek, 1981). In a study conducted by Neville et al. (1985), Angus, Santa Gertrudis, and Angus x Santa Gertrudis reciprocal crossbred bulls were mated to Polled Hereford cows and the performance of their progeny tested. The Santa Gertrudis-sired calves had higher ($P<.05$) postweaning average daily gains than Angus-sired calves.

Hargrove et al. (1983a) compared two zebu breeds, Brahman and Romana Red. They reported that the Brahman-sired steers had heavier initial feedlot weights, higher average daily gains, and required fewer days in the feedlot to reach slaughter weight and condition than did steers sired by Romana Red bulls.

Breed of Dam

Postweaning growth and feed efficiency (megacalories of metabolizable energy/kilogram gain) were determined for 798 steers of various breeds and breed crosses (Cundiff et al., 1984). They found that breed of dam affected ($P<.01$) initial weight, average daily gain, and growth rate. Hargrove et al. (1983a) conducted a study to evaluate feedlot performance and carcass characteristics of Brahman and Romana Red-sired steers out of Angus and F_1 Angus x Brown Swiss dams. Steers out of crossbred dams had heavier initial weights, higher average daily gains, greater total gains, and require a longer feeding period to reach slaughter condition than did the steers from Angus dams. Calves out of the crossbred dams also had a larger frame score and were heavier at each weight period. These results are in agreement with those of Pahnish et al. (1969), who reported that crossbred progeny from Brown Swiss dams had higher average daily gains than those from beef x beef crossbred dams. Hargrove et al. (1983b) evaluated feedlot performance of steers of nine breed types, produced from mating Angus, Brown Swiss, and F_1 Angus x Brown Swiss bulls in a dillel scheme to cows of the same three breed types. Steers out of Brown Swiss dams had the heaviest ($P<.05$) weight per day of age, those out of Angus dams the lightest, and steers out of the crossbred dams were intermediate to those from the straightbred dams. Efficiency of feed conversion was also affected ($P<.05$) by breed of dam. Steers from Angus dams were the most efficient, followed by those from the crossbreds and Brown Swiss dams, respectively.

Peacock et al. (1982) measured feedlot average daily gains of 455 crossbred steers. The steers were produced by mating Angus, Brahman, and Charolais bulls to straightbred cows of the same three breed groups and two-breed reciprocal F_1 crossbred cows. Maternal effects, due to additive and heterosis effects, were relatively small for feedlot gain with the exception of a negative additive maternal effect ($P<.05$) of -37 g per day for Brahman dams.

Factors Affecting Carcass Characteristics

Breed of Sire

Cole et al. (1964) studied steers of eight breeds and breed crosses to determine the effect of breed on production traits, carcass composition, and palatability. Steer progeny of Hereford and Angus cows mated to Brahman bulls were among the breed groups studied. The Brahman crossbred steers had acceptable carcass cutability, but usually were ranked low and next to purebred Brahmans for palatability. In general, they were intermediately between British breeds and purebred Brahmans in the traits studied. Purebred Brahmans had a high percentage of separable muscle but ranked last on palatability scores in another study comparing Brahman, Angus, and Charolais crosses (Peacock et al., 1979). These authors found that breed of sire affected ($P<.01$) chilled carcass weight, fat over the ribeye, ribeye area/100 kg hot carcass weight, estimated yield ratio, and carcass quality grade. Direct effects of the Brahman breed were negative for ribeye area, estimated retail yield, and quality grade. The direct effects of the Charolais breed were positive for chilled carcass weight and yield grade, but negative for fat over the ribeye and quality grade. Similar results were obtained in a follow-up study (Peacock et al., 1982) in which the reciprocal F_1 Angus x Brahman, Angus x Charolais, and Brahman x Charolais females were included. Koch et al. (1976) compared composition and quality characteristics of 1,121 steer carcasses, produced from mating Hereford and Angus cows to Hereford, Angus, Jersey, South Devon, Limousin, Charolais, and Simmental bulls. Breed of sire effect was significant for all carcass traits measured, including carcass weight, fat over ribeye, ribeye area, and yield grade. Breed of sire x breed of dam interactions were also significant for most carcass traits measured. The analyses of variance of quality measures and taste panel evaluations showed the breed of sire effect to be significant for quality grade, marbling, color of lean, texture of lean, and firmness of lean, but not significant for Warner-Bratzler shear force, flavor, or juiciness.

Crockett et al. (1979) studied carcass characteristics of calves sired by continental, Brahman, and Brahman-derivative (American) breeds. Carcass data from steers fed on a time-constant basis indicated that ribeye area, fat thickness, and yield grade were influenced by breed of sire ($P<.01$). The breed of sire x breed of dam interactions affected ribeye area ($P<.01$). Steers sired by bulls of the larger continental breeds produced larger ribeye areas ($P<.01$) than those sired by bulls of the American breeds. On the other hand, when comparing two zebu sire breeds, Brahman and Romana Red, Hargrove et al. (1983a) found no significant breed of sire effects for dressing percentage, quality grade, yield grade, fat over ribeye, ribeye area, or percentage of kidney, pelvic, and heart fat. They did find, however, that Romana Red-sired steers produced carcasses with more separable fat ($P<.0001$) and less separable lean ($P<.0151$) than the Brahman-sired steers. Breed of sire did not affect any sensory characteristics or Warner-Bratzler shear force values.

In a study involving Brahman and Hereford bulls mated to Hereford cows, Carroll et al. (1955) reported significant breed of sire effects for carcass characteristics. Brahman-sired steers dressed sigificantly higher (2.2%) than those sired by Hereford bulls. Hereford-sired steers were fatter and graded higher than those sired by Brahman bulls. Butler et al. (1956) reported that Brahman x Hereford crossbreds had a higher dressing percentage ($P<.01$) than straightbred Herefords. These results are in agreement with those reported by Black et al. (1934), who reported that steers with about one-half Brahman breeding had dressing percentages between 2 and 4% higher than Hereford and Shorthorn steers.

Comparisons of dressing percentages of cattle of beef and dairy types have yielded varying results. Branaman et al. (1962), Wellington (1971), and Koch et al. (1982) showed that dairy-beef crosses had lower dressing percentages than beef types, while Cole et al. (1963), Judge et al. (1965), and Urick et al. (1974) reported the opposite.

Breed of Dam

Peacock et al. (1979) conducted an experiment in which Angus, Brahman, and Charolais bulls were mated in all combinations to cows of the same breeds. Breed of dam effects were significant for chilled carcass weight, fat over the ribeye, estimated yield, and quality grade, but not for ribeye area. Angus dams had positive effects on fat over the ribeye and quality grade, but a negative effect on retail yield. Brahman dams had positive effects on retail yield and ribeye area, but negative effects on fat over the ribeye and quality grade. Charolais dams had a positive effect on chilled carcass weight, but negative effects on ribeye area and retail yield. Similar results were found when F_1 Angus x Brahman, Angus x Charolais, and Brahman x Charolais females were added to the experiment (Peacock et al., 1982). In addition, maternal heterosis effects were observed for chilled carcass weight and fat over the ribeye for F_1 Angus x Brahman dams ($P<.01$), and for chilled carcass weight in F_1 Angus x Charolais dams ($P<.05$). Koch et al. (1976) measured carcass composition and quality characteristics on 1,121 crossbred and straightbred steers. Breed of dam (Hereford and Angus) effects were significant for fat trim, fat thickness, ribeye area, and yield grade, but not for carcass weight and retail product. The Hereford as a breed of dam had positive effects on fat trim and yield grade, but negative effects on fat thickness and ribeye area. Breed of dam had significant effects on quality grade, marbling, lean maturity, color of lean, texture of lean, firmness of lean, and tenderness, but not on Warner-Bratzler shear force, flavor, and juiciness. The Hereford breed had positive effects on color of lean, texture of lean, and firmness of lean, but negative effects on quality grade, marbling, and tenderness.

Crockett et al. (1979) studied carcass characteristics of steers out of Angus, Brangus, and Hereford dams mated to bulls of continental, Brahman, and Brahman-derivative breeds. Breed of dam affected marbling, fat thickness, quality grade, yield grade ($P<.05$), and ribeye area ($P<.01$). Steers out of Brangus dams had significantly lower marbling scores and quality grades and more fat thickness and lower cutability grades than steers out of Angus and Hereford dams ($P<.01$). These results are consistent with other studies reviewed, and again demonstrate the negative effect of Brahman breeding on marbling score, quality grade, and cutability. Luckett et al. (1975) showed significant but low correlations between Warner-Bratzler shear force values and quality grade (-.21) and marbling score (-.13). They also found that Brahman steers were less tender ($P<.01$) than Angus, Charolais, and Hereford steers.

Hargrove et al. (1983b) compared carcass characteristics of Angus, Brown Swiss, and F_1, F_2, and backcross Angus x Brown Swiss crossbred steers. Breed of sire and breed of dam affected ribeye area. However, when ribeye area was expressed as cm^2/100 kg hot carcass weight, the differences due to breed of sire and breed of dam were not significant. This indicates that steers from the Brown Swiss dams had larger ribeye areas because they had heavier carcasses. Steers from Brown Swiss dams had heavier hot carcass weights and larger ribeye areas than steers from Angus dams. Steers produced by F_1 dams were intermediate for the same traits. In a study comparing Angus and F_1 Brown Swiss x Angus dams (Robinson, 1984), breed of dam did not affect marbling score, quality grade, yield grade, or percentage of kidney, pelvic, and heart fat. As in the results reported by Hargrove et al. (1983a), steers from F_1 dams produced carcasses with a larger ($P<.0033$) average ribeye area than did steers from Angus dams. However, when ribeye area was expressed on a 100 kg carcass weight basis, the difference between the two dam breeds was reversed, with steers from Angus dams producing carcasses with larger ribeye areas/100 kg hot carcass weight than those from the F_1 dams. Carcasses of steers from F_1 dams contained less ($P<.0336$) separable fat than carcasses of steers from Angus dams. There was no difference between the two breeds of dam in percentages of separable lean and bone. Loin steaks of steers from Angus dams had lower ($P<.0385$) Warner-Bratzler shear force values and contained less ($P<.0631$) detectable connective tissue than those from F_1 dams. In another study comparing dairy and beef breeds, Ziegler et al. (1971) also found a tendency for steers out of Holstein dams to be less tender than steers out of dams of the British beef breeds, but more tender than those out of the Charolais dams.

Age at Weaning

Very little information has been published on the effect of age at weaning on carcass characteristics. Most information available was not obtained by making age at weaning a planned experimental variable, but by using the age differences of calves born in a calving season. Depending on the length of the breeding season, this age difference could range from 2 to 4 months. An example of such an analysis is the report by Crockett et al. (1979). In this study, the calving season was from November 26 to February 10. Weaning age was found to have a significant effect ($P<.01$) on fat thickness but not on marbling score, ribeye are, quality grade, or yield grade.

EXPERIMENTAL PROCEDURE

Description of Data

The data used in this study were obtained, over a two-year period, at the Beef Research Unit (BRU) of the University of Florida, Gainesville. Data were collected on 125 cow-steer pairs (67 in 1983-84 and 58 in 1984-85). There were two main treatments in the study: these were (1) early weaning treatment, weaned at an average age of 7 months, and (2) late weaning treatment, weaned at an average age of 9 months. Within years, calves within breed of sire and breed of dam groups were alternately assigned by birth date to the two treatments. Steer calves used in this experiment were crossbreds sired by Brahman and Romana Red bulls and out of Angus and Brown Swiss x Angus F_1 and F_2 crossbred cows. Cows were three years of age and older. All had calved first at two years of age and each year thereafter. Birth dates of calves ranged from early January to mid-March, with births concentrated (65%) between January 21 and February 12. Cows were wintered, after calving, on 20 kg corn silage, 1 kg molasses, and .5 kg cottonseed meal per head per day. Supplemental feeding was stopped at the time the bahiagrass (Paspalum notatum Flügge) and white clover (Trifolium repens L.) pastures were adequate to provide the required level of nutrition. The pastures were predominately bahiagrass by late June. The stocking rate was about 1.3 acre/cow-calf unit. A complete mineral mixture was supplied ad libitum to all animals throughout the experimental period.

Calves were weighed and implanted with 36 mg of Ralgro at about 60 days of age (end of March). In the first year of the study, calves were stratified by weaning age treatment and breed group to one of the following Ralgro implant treatments: (1) 60-day interval between implants--three implants preweaning, and (2) 90-day interval between implants--two implants preweaning. The cow-calf pairs were assigned within breed type, Ralgro treatment, and weaning age to one of three pastures. Preliminary analyses showed no significant difference between the 60- and the 90-day Ralgro treatments for year 1; thus, the 60-day interval was dropped from the experiment the second year. The number of calves by year, breed of sire, breed group of dam, and weaning age group is shown in table 1.

Calves were weighed and given ad libitum access to creep feed from about 150 days of age until their respective weaning dates. The creep feed fed until the early weaning date was a commercial mixture containing 14% crude protein, not more than 8% crude fiber, not less than 2.5% crude fat, and 900 U.S.P. units of vitamin A per .45 kg. From the early weaning date until slaughter all steers were switched to a feedlot diet with 10.6% protein. The first year, this

Table 1. NUMBER OF STEERS BY BREED OF SIRE, BREED OF DAM, YEAR, AND WEANING AGE.

Breed of sire	Weaning age	Breed of dam			
		Angus		SA[a]	
		1983	1984	1983	1984
Brahman	7 months	5	5	10	6
	9 months	6	5	9	7
Romana Red	7 months	7	6	11	11
	9 months	6	6	13	12

[a] Brown Swiss x Angus F_1 and F_2 crossbreds.

diet consisted of 23% corn silage (IFN 3-28-246), 75% high moisture corn (IFN 4-20-770), and 4% commercial protein pellets (52% CP) with monensin. Due to unsatisfactory gains, this diet was changed the second year to one with 12.2% protein, consisting of 79% high moisture corn (IFN 4-20-770), 12% cottonseed hulls (IFN 1-01-5-9), 5% molasses (IFN 4-04-696), and 4% commercial protein pellets (52% CP) with monensin. Dry matter and energy contents for the feedlot diets were 73% and 3.15 ME/kg in 1983 and 76% and 3.75 ME/kg in 1984. Energy content of feed was determined in an adiabatic bomb calorimeter.

At weaning, the early-weaned calves were put into feedlot pens, following a 5-day period in the corral during which all animals were fed a mixture of the commercial creep feed and the feedlot diet, with a daily increase of the latter to 100% by day four postweaning. This gradual change from the creep diet to the feedlot diet was made simultaneously for the calves who remained with their dams until 9 months of age.

In 1983 steers were placed into feedlot pens according to weaning age, preweaning Ralgro treatment, and breed of dam. The following year steers were placed according to weaning age, breed of sire, and breed of dam.

At 8 months of age steers were implanted with 220 mg of Synovex-S (Syntex Agribusiness, Inc., Des Moines, IA). In the feedlot, steers were weighed periodically to monitor performance. Steers were fed to an estimated 1 cm outside fat, weighed, and transported to the University of Florida Meats Laboratory the day before slaughter. There they had access to water but not feed for approximately 24 hours. Steers were weighed just prior to slaughter. The last weight obtained in the feedlot, one day before slaughter, is referred to in the text as final weight and the weight obtained at the meats laboratory prior to slaughter is referred to as slaughter weight. Immediately after slaughter the gastrointestinal tract was weighed, emptied, washed, and reweighed. Hide weight and hot carcass weight were also recorded.

Carcasses were ribbed between the 12th and the 13th ribs about 24 hours post-slaughter. The carcass data collected included (1) maturity of bone and lean, (2) marbling score, (3) texture and color of lean, (4) heat ring, (5) color of fat, (6) outside fat, (7) percent KPH fat, and (8) ribeye area.

The 9-10-11 rib section from the right side of each carcass was removed 24 hours postmortem, using the procedure outlined by Hankins and Howe (1946), vacuum packaged, and stored at -18 C for subsequent physical separation. The 9-10-11 rib sections were physically separated into lean, fat, and bone after being thawed at 4 to 5 C. The physical separation data for fat, bone, and lean tissue were used to predict carcass composition using the equations of Hankins and Howe (1946), where % fat = 3.54 + .80X (X = weight of separable fat from the 9-10-11 rib section), % lean =

16.08 + .80X (X = weight of separable lean), and % bone = 5.52 + .57X (X = weight of separable bone).

Two, 2.54 cm loin steaks were removed from the short loin 24 hours postmortem for sensory panel evaluation. In addition, a third loin steak, 2.54 cm thick, was removed for shear force determination, using a Warner-Bratzler shear device. The steaks were individually wrapped and kept at 2 to 4 C for 7 days and then stored at -18 C until sensory panel and shear evaluations. All steaks were handled and cooked according to the procedure outlined by the AMSA (1978) guidelines. Steaks were grilled on an open electric broiler, turned at 40 C internal temperature, and removed from the broiler at 70 C. Internal temperature was monitored using copper-constantine thermocouples attached to a Speedmax W Multipoint Recorder. Samples (1 X 1 X 2 cm) were removed from the cooked steaks and evaluated by a trained sensory panel for flavor (8 = extremely intense; 1 = extremely bland), juiciness (8 = extremely juicy; 1 = extremely dry), tenderness (8 = extremely tender; 1 = extremely tough), and amount of connective tissue (8 = none; 1 = abundant). Six core samples (1.27 cm diameter) were removed, from steaks cooled to room temperature, for shear force determination. The average of the six samples were used in the statistical analyses that followed.

Statistical Analyses

Calf data were analyzed by least-squares, fixed model procedures using the Statistical Analysis System (SAS, 1982). The model used to analyze calf preweaning performance included the main effects of year, breed of sire, breed group of dam, and all possible two- and three-way interactions. Age of dam and age of calf were used as covariates. Outside fat thickness was used as a covariate in the analyses of feedlot performance and carcass characteristics.

Cow response traits analyzed were weight and condition score changes between the two weaning dates. The model used for analyses of cow traits included the effect due to breed group of dam, breed of sire of calf, pasture, and weaning age treatment. All possible interactions between breed group of dam, breed of sire of calf, and weaning age treatments were always included in the model, but all other interactions were only included if significant.

RESULTS AND DISCUSSION

Steer Performance to Seven Months of Age

All steer calves were treated equally during the period from birth to early weaning at 7 months of age. Traits measured in this period were birth weight, weight at 5 months of age, gain from 5 to 7 months of age, and age at the early weaning date. Least squares estimates, standard errors, and probability values for these traits are shown in table 2. Also, measured in this period were creep feed consumption from the beginning of the creep feeding period to the early weaning date and creep feed to gain ratio (table 3). Brahman-sired steer calves were 4 kg heavier ($P<.0001$) at birth than those sired by Romana Red bulls. The effect of breed of dam on birth weight was similar to that of breed of sire. Calves from Brown Swiss x Angus dams were 4 kg heavier ($P<.0002$) than those from Angus dams. These findings are not in accordance with those reported by Koch and Clark (1955) and Laster and Gregory (1973). Each of these studies found the effect of breed of dam on birth weight to be greater than that of breed of sire. This was attributed to the fact that the dam contributes one-half of the genotype of the calf plus an environmental component through the size and other influences of the uterus.

TABLE 2. LEAST SQUARES ESTIMATES ± STANDARD ERRORS AND PROBABILITY VALUES (P) FOR BIRTH WEIGHT, 5-MONTH WEIGHT, AVERAGE DAILY GAIN FROM 5 TO 7 MONTHS OF AGE, AND AGE OF CALF AT THE EARLY WEANING DATES

Source of variation	Birth weight, kg	5 month weight, kg	Average daily gain 5 to 7 months, kg	Age at early weaning date, days
Weaning age				
7 month	36 ± .69	193 ± 3.2	1.33 ± .03	212 ± 2.1
9 month	37 ± .69	195 ± 3.2	1.35 ± .03	211 ± 2.1
P	.2352	.6603	.5490	.7019
Breed of sire				
Brahman	39 ± .71	206 ± 3.4	1.37 ± .02	217 ± 2.2
Romana Red	35 ± .63	182 ± 3.0	1.31 ± .02	207 ± 2.0
P	.0001	.0001	.1299	.0008
Breed of dam				
Angus	35 ± .80	186 ± 3.8	1.29 ± .03	215 ± 2.5
SA[a]	39 ± .61	203 ± 2.9	1.38 ± .02	208 ± 1.9
P	.0003	.0013	.0402	.0239
Year				
1983	37 ± .65	193 ± 3.1	1.30 ± .03	212 ± 2.0
1984	37 ± .69	195 ± 3.3	1.38 ± .03	211 ± 2.2
P	.9343	.6803	.0302	.7631

[a] Brown Swiss x Angus reciprocal F_1 and F_2 crossbreds.

TABLE 3. CREEP FEED CONSUMPTION FROM THE BEGINNING OF THE CREEP FEEDING PERIOD TO EARLY WEANING (5 TO 7 MONTHS OF AGE)

Parameter	Year	
	1983	1984
Number of steers	68	59
Total per calf		
As fed, kg	162	217
Dry matter, kg[a]	141	189
Per calf/day		
As fed, kg	3.00	3.55
Dry matter, kg[a]	2.61	3.09
Grain per calf		
Total, kg	80	81
Per day, kg	1.48	1.33
Feed conversion		
As fed, kg	2.03	2.68
Dry matter, kg	1.76	2.36

[a] Dry matter of creep feed = 87% for both years.

The differences found in the present study are probably due to the fact that different breeds were involved, and that this study only considered steer calves. Table 2 also shows significant breed of sire and breed of dam effects for weight at 5 months of age. Brahman-sired steer calves weighed 25 kg more ($P<.0001$) than those out of Angus dams. These results concur with those reported by Prichard (1983), who reported the only data found which compared Brahman and Romana Red sires. He reported that Brahman-sired calves had a larger frame size and were heavier at each preweaning weigh-period than those sired by Romana Red bulls.

Birth weight is an important trait to measure because it is highly correlated with weaning weight and postweaning gain. Sagebiel et al. (1969) reported that calves with the heaviest birth weights usually maintained that advantage until weaning. However, as birth weight increases so does the likelihood of dystocia or difficult birth. It should be the objective of any cattleman to select animals for increased weaning weight and not increased birth weight. While this is not easily accomplished, Koch et al. (1974) reported that the increase in birth weight could be reduced by 30% if all emphasis on growth was directed toward selection for postnatal growth rather than weaning or yearling weight.

The weight superiority of Brahman-sired calves over the Romana Red-sired calves at birth and at 5 months of age was expected, since Brahman animals are larger framed and, in this study, averaged 10 days older at weaning. Similarly, the superiority of calves from Brown Swiss x Angus dams over those from Angus dams was expected because of the larger frame size of the crossbred dams and the extra milk production due to the Brown Swiss breeding.

Creep feeding was started for all calves at the time the 5-month weight was taken. Breed of sire tended to affect weight gain from 5 to 7 months of age ($P<.1299$), 1.4 and 1.3 kg per day, respectively, for Brahman and Romana Red-sired calves. Calves nursing Brown Swiss x Angus dams gained 13 kg more from birth to 5 months of age ($P<.0426$) than those nursing Angus dams. Calf growth potential and milk consumption were partially confounded in this study by the fact that larger calves were nursing the dams with higher milk production. The Brown Swiss x Angus dams produced about 3 kg per day more milk than did the Angus dams (Euclides et al., 1983). It is, therefore, difficult to separate growth potential due to breed size from growth due to milk consumption. Isea (1985) estimated that an increase of 1 kg in average daily milk yield of Brown Swiss x Angus crossbred cows would result in an increase of 7.0 kg in 205-day calf weight. Ochoa et al. (1981), on the other hand, suggested that creep feeding tended to mask milk production differences among cows, and that calves nursing poorer milking dams probably compensated by eating more creep.

There was no significant difference between years for birth weight, 5-month weight, or age at the early weaning date. Average daily gain did, however, differ (P<.0302) between years. Calves born in 1984 gained more than did the calves born in 1983.

Creep consumption per calf, from 5 to 7 months of age, was 162 and 217 kg in 1983 and 1984, respectively (table 3), and, on a daily basis, this was about 3.00 and 3.55 kg per calf. The reason for the increase in daily consumption per calf is unknown, especially since the pastures appeared to be in better condition in 1984. Gains from 5 to 7 months of age were about the same for both years, resulting in better feed efficiency in 1983.

Steer Performance from 7 to 9 Months

Table 4 shows the least squares estimates, standard errors, and probability values for 7- and 9-month weights and condition scores, and adjusted 205- and 265-day weights. There were no significant differences between calves weaned at 7 and 9 months of age for any of the traits listed in the table. Breed of dam and breed of sire, however, did affect all traits. Brahman-sired steers were heavier at 7 and 9 months of age (P<.0001) than those sired by Romana Red bulls. Part of this weight difference was due to the fact that, in this study, the Brahman-sired steers were an average of 10 days older at each weaning date than were those sired by Romana Red bulls (table 2). When weights

TABLE 4. LEAST SQUARES ESTIMATES ± STANDARD ERRORS AND PROBABILITY VALUES (P) FOR 7 AND 9 MONTH WEANING WEIGHTS, ADJUSTED 205- AND 265-DAY WEIGHTS, AND CONDITION SCORES

Source of variation	Number of steers	7-month weight, kg	Adjusted 205-day weight, kg	7-month condition score[a]	9-month weight, kg	Adjusted 265-day weight, kg	9-month condition score[a]
Weaning age							
7 months	61	274 ± 3.6	266 ± 3.1	9.7 ± .12	336 ± 4.5	330 ± 4.2	10.5 ± .16
9 months	64	277 ± 3.7	270 ± 3.2	9.8 ± .13	336 ± 4.6	332 ± 4.3	10.1 ± .17
P		.5187	.3246	.4431	.9817	.7803	.1170
Breed of sire							
Brahman	53	289 ± 3.8	276 ± 3.3	9.5 ± .13	352 ± 4.8	341 ± 4.5	10.1 ± .17
Romana Red	72	262 ± 3.4	261 ± 3.0	10.0 ± .11	320 ± 4.3	321 ± 4.0	10.6 ± .16
P		.0001	.0008	.0062	.0001	.0013	.0243
Breed of dam							
Angus	46	265 ± 4.3	254 ± 3.7	10.3 ± .15	327 ± 5.4	318 ± 5.1	11.1 ± .20
SA[b]	79	286 ± 3.2	283 ± 2.8	9.3 ± .11	344 ± .41	343 ± 3.8	9.5 ± .15
P		.0002	.0001	.0001	.0207	.0003	.0001
Year							
1983	67	274 ± 3.5	266 ± 3.0	9.3 ± .12	325 ± 4.4	324 ± 4.1	10.7 ± .16
1984	58	277 ± 3.8	270 ± 3.3	10.3 ± .13	346 ± 4.7	337 ± 4.4	9.9 ± .17
P		.5876	.4166	.0001	.0019	.0258	.0013

[a] 17 point scale where 9 = >.55 cm but <.70 cm of fat over the 12-13th rib; 10 = >.70 cm but <.85 cm of fat over the 12-13th rib; and 11 = >.85 cm but <1.00 cm of fat over the 12-13th rib.

[b] Brown Swiss x Angus reciprocal F_1 and F_2 crossbreds.

were adjusted to constant ages of 205 and 265 days, the weight difference decreased but remained significant. Prichard (1983) also found Brahman-sired calves to be heavier (P<.001) at 7 months of age than those sired by Romana Red bulls. Condition scores at 7 and 9 months of age were significantly higher for Romana Red-sired steers than those sired by Brahman bulls. Steers out of Angus dams had higher (P<.0001) condition scores than those out of Brown Swiss x Angus dams at both the early and the late weaning dates. These results are different than those reported by Prichard (1983). He studied the same breed groups and found no breed of sire or breed of dam effect on the 7-month condition score. Year differences were significant for 7-month condition score, 9-month weight, adjusted 265-day weights, and 9-month condition score but not for 7-month and adjusted 205-day weights. At 7 months of age condition scores were higher (P<.0001) in 1984 than in 1983. This situation reversed for condition scores taken at 9 months of age. A possible explanation may be that in 1983 creep feed was fed for a longer period before switching to the feedlot diet. Also, the graders in 1983 were different from those used at the late weaning date in 1984.

Steer weight gain and condition score changes from 7 to 9 months of age are shown in table 5. Weaning age group, breed of sire, and breed of dam did not affect (P>.1672) weight gain or average daily gain from 7 to 9 months of age. The early- and late-weaned groups gained 62 and 58 kg,

TABLE 5. LEAST SQUARES ESTIMATES ± STANDARD ERRORS AND PROBABILITY VALUES (P) FOR WEIGHT AND CONDITION SCORE CHANGES FROM 7 TO 9 MONTHS OF AGE

Source of variation	Total weight gain, kg[a]	Average daily gain kg[b]	Condition score change
Weaning age			
7 months	62 ± 2.30	1.07 ± .04	.8 ± .13
9 months	58 ± 2.38	1.01 ± .04	.3 ± .14
P	.3389	.3447	.0085
Breed of Sire			
Brahman	62 ± 2.47	1.08 ± .04	.6 ± .14
Romana Red	58 ± 2.19	1.00 ± .04	.6 ± .13
P	.1879	.1892	.9469
Breed of Dam			
Angus	62 ± 2.77	1.08 ± .05	.8 ± .16
SA[c]	58 ± 2.10	.99 ± .04	.3 ± .12
P	.1843	.1672	.0062
Year			
1983	51 ± 2.25	.95 ± .04	1.4 ± .13
1984	69 ± 2.42	1.13 ± .04	-.3 ± .14
P	.0001	.0023	.0001

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[a] Breed of sire x breed of dam x weaning age group interactions affected weight gain, P<.0391.

[b] Breed of sire x breed of dam x weaning age group interactions affected average daily gain, P<.0392.

[c] Brown Swiss x Angus reciprocal F_1 and F_2 crossbreds.

respectively, in the 2-month period from the early to the late-weaning dates. Weaning age and breed group of dam affected (P<.0085) condition score change but breed of sire did not (P>.9469). The early weaned group increased more in condition score than did those weaned 2 months later. This increase in condition score may not have been a real increase, because there was no increase in weight gain, but may have been caused by switching graders on the late weaning date in 1984. Year effect was significnat for weight gain, average daily gain, and condition score change from the early to the late weaning dates.

Concentrate diet consumption, gain per steer, and feed conversion for the period from 7 to 9 months of age are presented in table 6. Feed efficiency could not be analyzed because steers were not fed in the same groups over the two years and, thus, not replicated. The values in the table are calculated averages based on group consumption. For the periods from 7 to 9 months of age, concentrate consumption per steer was higher in 1984 than 1983 for both the early- and late-weaned groups. This was probably a result of switching feedlot diets from the one fed in 1983, which consisted mainly of corn silage (23%) and high moisture corn (71%), to one consisting of mainly high moisture corn (79%) and cottonseed hulls (12%), which was fed in 1984. The latter diet was consumed better and had a higher energy content (3.75 ME/kg) than the corn-corn silage mixture (3.15 ME/kg) and resulted in higher weight gains for both the

TABLE 6. CONCENTRATE DIET CONSUMPTION, GAIN PER STEER, AND FEED CONVERSION BY WEANING AGE AND YEAR FOR DIFFERENT TIME PERIODS

Item	7 to 9 months of age[a]				9 months to slaughter[b]				7 months to slaughter			
	Early weaned		Late weaned		Early weaned		Late weaned		Early weaned		Late weaned	
	1983	1984	1983	1984	1983	1984	1983	1984	1983	1984	1983	1984
Consumption per steer, kg												
As fed	416	537	259	337	1689	1044	1580	1183	2105	1581	1839	1520
Dry matter	306	408	204	256	1233	793	1153	899	1536	1201	1342	1155
Energy[c]	---	---	---	---	5320	3915	4977	4436	---	---	---	---
Feed per steer per day, kg												
As fed	7.7	8.8	4.8	5.5	14.3	12.0	12.4	15.0	12.0	11.0	10.3	10.4
Dry matter	5.7	6.7	3.8	7.2	10.4	9.1	9.1	11.3	8.7	8.3	8.3	7.9
Energy[c]	---	---	---	---	45.1	45.0	39.2	56.2	---	---	---	---
Gain per steer, kg												
Total	53.7	69.9	48.8	68.1	112	101	118	102	165	171	167	170
Per day	.99	1.14	.91	1.12	.94	1.15	.93	1.23	.94	1.18	.94	1.16
Feed conversion, kg												
As fed	7.7	7.7	5.3	4.9	15.1	10.3	13.4	11.6	12.8	9.2	11.0	8.9
Dry matter	5.7	5.8	4.2	3.8	11.0	7.8	9.7	8.8	9.3	9.2	8.0	6.8
Energy[c]	---	---	---	---	47.6	38.8	42.1	43.5	---	---	---	---

[a] The sum of creep feed and feedlot ration (dry matter of creep feed = 87% and dry matter of feedlot ration = 73% in 1983 and 76% in 1984).

[b] Feedlot ration only (73 and 76% dry matter for 1983 and 1984, respectively).

[c] Energy for feedlot ration = 3.15 ME/kg in 1983 and 3.75 ME/kg in 1984.

early- and late-weaned groups. Joanning et al. (1981) observed poor performance in steers fed a ratio of 1:2 corn silage-corn grain mixtures. They found that the dry matter digestion coefficients for the silage-grain mixtures averaged 11% less ($P<.01$) than those calculated from the weighted means of the feeds when fed singly. These data suggested a negative associative effect between cracked corn grain and corn silage, when intake ranged from 2.4 to 3.1 times maintenance. Incomplete starch digestibility was apparently the major reason for the decreased efficiency observed when corn silage and corn grain were fed as mixtures. Table 7 shows the weighted averages over years for concentrate consumption, gain per steer, and feed efficiency. Early-weaned steers consumed an average of 180 kg more of the diet per steer than did the late-weaned group from 7 to 9 months of age. And since weight gain was about the same for the two weaning age groups, the lower feed consumption resulted in better feed conversion to gain and lower feed costs for the late weaned group.

Dam Performance

An important phase of this study was to determine the effects of early versus late weaning of the calf on dam performance. There can be no net benefit from late weaning if it has a detrimental effect on dam performance. To measure the effects of the weaning age treatment on dam performance, all dams were weighed and condition scored at

TABLE 7. CONCENTRATE DIET CONSUMPTION, GAIN PER STEER, AND FEED CONVERSION BY WEANING AGE FOR DIFFERENT TIME PERIODS

Item	7 to 9 months of age[a]		9 months to slaughter		7 months to slaughter[a]	
	Early weaned	Late weaned	Early weaned	Late weaned	Early weaned	Late weaned
Consumption per steer, kg						
As fed	480	300	1415	1427	1895	1727
Dry matter	360	231	1406	1055	1406	1286
Energy[b]	---	---	4723	4764	---	---
Consumption per calf per day, kg						
As fed	8.3	5.2	14.0	14.3	12.0	10.7
Dry matter	6.2	4.0	10.4	10.6	8.9	7.9
Energy[b]	---	---	43.3	40.2	---	---
Gain per calf, kg						
Total	62	58	106	110	168	168
Per	1.07	1.01	1.04	1.04	1.06	1.04
Feed conversion, kg[c]						
As fed	7.7	5.1	13.3	13.0	11.3	10.2
Dry matter	5.8	3.9	9.9	9.5	8.3	7.6
Energy[b]	---	---	46.8	43.3	---	---

[a] The sum of creep feed and feedlot ration (dry matter of creep feed = 87% and dry matter of feedlot ration = 73% in 1983 and 76% in 1984).

[b] Energy for feedlot ration = 3.15 ME/kg in 1983 and 3.75 ME/kg in 1984.

[c] kg diet per kg liveweight gain.

each of the two weaning periods to determine the change in those traits between the two weaning dates. Table 8 shows least squares estimates, standard errors, and probability values for dam weights and condition scores for the early- and late-weaning periods, and for weight and condition score changes between the early and late weaning dates. Pregnancy rates are also presented in this table.

Dams whose calves were weaned at 9 months of age were lighter ($P<.05$) (451 vs 470 kg) and thinner ($P<.001$) in condition (5.9 vs 6.5) at the late weaning date than dams whose calves were weaned 2 months earlier. Hancock et al. (1985) also found that dams whose calves were weaned late were lighter and thinner than those whose calves were weaned at an earlier date.

Weaning age treatment affected ($P<.0001$) dam weight change and condition score change between the early and late weaning dates. Dams whose calves were weaned early gained an average of 16 kg, while dams whose calves were not weaned until 2 months later, lost an average of 1 kg in the period between early and late weaning. Similar results were reported by Pate et al. (1985). He found that Brangus-type cows whose calves were weaned at 8.5 months of age gained 14 kg more than cows whose calves were weaned at 10.5 months of age. Table 8 also shows that Brown Swiss x Angus crossbred dams were 38 and 34 kg heavier ($P<.001$) than the Angus dams at the early and late weaning dates, respectively. This is not surprising since the Brown Swiss breed is larger framed

TABLE 8. LEAST SQUARES ESTIMATES ± STANDARD ERRORS AND PROBABILITY VALUES (P) FOR DAM WEIGHTS, CONDITION SCORES, WEIGHT AND CONDITION SCORE CHANGES BETWEEN EARLY- AND LATE-WEANING DATES (AUGUST AND OCTOBER, RESPECTIVELY), AND PREGNANCY RATE

Source variation	Dam weight in August, kg	Dam weight in October, kg	Dam weight change Aug to Oct	Dam condition in August[a][b]	Dam condition in October[c]	Dam condition change Aug to Oct[d]	Pregnancy rate[e] %
Weaning age							
7 months	454 ± 5.9	470 ± 6.6	16 ± .02	6.7 ± .13	6.5 ± .12	-.2 ± .09	96 ± .04
9 months	452 ± 6.1	451 ± 6.8	-1 ± .02	6.6 ± .14	5.9 ± .13	-.7 ± .10	88 ± .04
P	.8303	.0435	.0001	.8099	.0011	.0001	.2151
Cow breed							
Angus	434 ± 7.2	443 ± 7.9	8 ± .02	7.3 ± .16	6.9 ± .15	-.4 ± .11	90 ± .05
SA[f]	471 ± 5.4	477 ± 6.1	6 ± .02	6.0 ± .12	5.5 ± .11	-.5 ± .08	94 ± .04
P	.0001	.0012	.4099	.0001	.0001	.7112	.6007
Sire breed of calf							
Brahman	455 ± 6.4	463 ± 7.0	8 ± .02	6.7 ± .15	6.4 ± .13	-.3 ± .10	90 ± .04
Romana Red	450 ± 5.7	457 ± 6.3	7 ± .02	6.6 ± .13	6.0 ± .12	-.6 ± .09	94 ± .04
P	.7201	.5403	.8453	.5260	.0249	.0421	.5162
Year							
1983	447 ± 5.8	460 ± 6.2	13 ± .02	6.6 ± .13	6.4 ± .12	-.2 ± .09	93 ± .04
1984	460 ± 6.3	461 ± 7.1	1 ± .02	6.8 ± .14	6.0 ± .13	-.8 ± .10	90 ± .04
P	.1464	.9102	.0001	.2793	.0149	.0001	.5567

[a] 17 point scale where 5 = thrifty, pin bones not covered; 6 = <.25 cm of fat over 12-13th rib, pin bone covered, last 2-3 ribs showing; 7 = >.25 cm but <.50 cm of fat over 12-13th rib.

[b] Sire breed of calf x breed of dam interactions affected dam condition in August (P<.0647).

[c] Sire breed of calf x breed of dam interactions affected dam condition in October (P<.0027).

[d] Breed of dam x weaning age group interactions affected dam condition change between August and October (P<.0848).

[e] Pregnancy rate for the following breeding season following weaning of calf.

[f] Brown Swiss x Angus reciprocal F_1 and F_2 crossbreds.

than the Angus breed. The overall change in weight was, however, not different (P>.40) for the cow dam breed groups. Body condition scores, on the other hand, were lower (P<.0001) for the Brown Swiss x Angus dams than for the Angus dams at both the early and late weaning dates (6.0 vs 7.3 and 5.5 vs 6.9, respectively). This was probably a result of the dairy breeding and, thus, higher milk production of the Brown Swiss x Angus crossbred dams. Belcher and Frahm (1979), who studied Angus and Hereford cows mated to Hereford, Angus, Simmental, Brown Swiss, and Jersey bulls, also indicated that cows with higher milk yields lost more weight during lactation. However, the overall change in body condition between the early and late weaning dates was not affected (P>.71) by breed group of dam.

Sire breed of calf had no significant effect on dam weight at the early and late weaning dates or on weight change between the two weaning dates. Dams nursing Brahman-sired calves did not differ (P>.52) in condition score at the early weaning date from those nursing Romana Red-sired calves, but did differ (P<.03) in condition score at the late weaning date (P<.05). Dams whose calves were sired by Romana Red bulls lost more condition (.6 vs .3) than those dams whose calves were sired by Brahman bulls. The reason for this is unknown and unexpected, since the Brahman-sired calves weighed significantly more than the Romana Red-sired calves and also gained slightly more between the early and the late weaning periods (tables 4 and 5).

Year effect was significant for both dam weight change and condition score change between the early and late weaning dates. In the 2-month period between the early and late weaning dates, dams gained an average of 13 kg and 1 kg in 1983 and 1984, respectively. This weight gain was accompanied by condition score losses of .2 and .8 of a condition score. There were significant breed of dam x sire breed of calf interactions for dam condition scores at the early and late weaning dates, and significant breed of dam x weaning age group interactions for dam condition score change between the early and the late weaning dates. The breed of dam x sire breed of calf interactions for dam condition score at the early weaning date are presented in table 9. At the early weaning date, Angus dams had higher condition scores than the Brown Swiss x Angus crossbred dams, irrespective of sire breed of calf. The difference in condition score between Angus and Brown Swiss x Angus crossbred dams was greater when the cows were nursing Brahman-sired calves than when nursing calves sired by Romana Red bulls. Angus dams nursing Brahman-sired calves had a higher condition score than those nursing Romana Red-sired calves, even though the Brahman-sired calves were heavier than those sired by Romana Red bulls. On the other hand, Brown Swiss x Angus crossbred dams nursing

TABLE 9. LEAST SQUARES ESTIMATES ± STANDARD ERRORS FOR DAM CONDITION SCORE AT THE EARLY WEANING DATE (AUGUST), BY BREED OF COW AND SIRE BREED OF CALF[a]

Sire breed of calf	Breed of cow	
	Angus	Brown Swiss x Angus
Brahman	7.5 ± .23	5.9 ± .18
Romana Red	7.1 ± .23	6.1 ± .15

[a] Sire breed of calf x breed of dam interactions affected dam condition score at early weaning date ($P<.0647$).

Brahman-sired calves had a lower condition score than those nursing Romana Red-sired calves.

Breed of cow x sire breed of calf interactions affected dam condition score at the late weaning date (table 10). These data show the same trend as those in table 9. At the late weaning date there was almost no difference in condition score between Brown Swiss x Angus dams nursing Brahman-sired calves and those nursing Romana Red-sired calves.

Breed of dam x weaning age group interaction effects for dam condition change between the early and the late weaning dates are presented in table 11. Dam condition change was smaller for the group whose calves were weaned early as compared to those whose calves were weaned 2 months later. This was expected because dams whose calves were weaned early stopped producing milk and were able to maintain body condition better than the dams whose calves were not weaned. Brown Swiss x Angus dams in the late weaning group lost more condition than did the Angus dams because they were probably producing more milk than the Angus dams. Milk production was not measured in this study, but in another study using the same breed groups, Euclides et al. (1983) reported that F_1 dams produced about 3 kg more milk per day than did the Angus dams. Belcher and Frahm (1979) also reported that Brown Swiss x Angus crossbred cows produced more milk than Brown Swiss x Hereford, Jersey x

TABLE 10. LEAST SQUARES ESTIMATES ± STANDARD ERRORS FOR DAM CONDITION SCORE AT THE LATE WEANING DATE (AUGUST), BY BREED OF COW AND SIRE BREED OF CALF[a]

Sire breed of calf	Breed of cow	
	Angus	Brown Swiss x Angus
Brahman	7.4 ± .20	5.5 ± .17
Romana Red	6.4 ± .20	5.6 ± .14

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[a] Sire breed of calf x breed of dam interactions affected dam condition score at late weaning date ($P<.0027$).

TABLE 11. LEAST SQUARES ESTIMATES ± STANDARD ERRORS FOR DAM CONDITION SCORE CHANGE BETWEEN EARLY AND LATE WEANING DATES, BY BREED OF COW AND SIRE BREED OF CALF[a]

Sire breed of calf	Breed of cow	
	Angus	Brown Swiss x Angus
Brahman	-.3 ± .15	-.1 ± .12
Romana Red	-.6 ± .16	-.9 ± .11

[a] Breed of dam x sire breed of calf interactions affected dam condition score change between the early and late weaning date.

Hereford, Simmental x Angus, Jersey x Angus, and Simmental x Hereford crossbred cows.

Another method for determining the effects of early weaning versus late weaning on dam performance is to measure pregnancy rates in subsequent years (table 8). Pregnancy rate was not affected (P>.10) by weaning age treatment, dam breed, sire breed of calf, or year. There was a tendency, however, for the dams whose calves were late weaned to have a lower pregancy rate than those whose calves were weaned 2 months earlier (88 vs 96%). Pate et al. (1985) also reported no effect (P>.10) of weaning age (8.5 vs 10.5 months of age) on pregnancy rate of Brangus-type cows, but he did report a 1% higher pregnancy rate for those cows whose calves were weaned at 10.5 months. This difference was most likely due to the fact that these dams were fed molasses during the experiment and, thus, were able to gain back more weight prior to calving again.

Steer Performance in the Period from 7 Months of Age to Slaughter and 9 Months of Age to Slaughter

Least squares estimates, standard errors, and probability values for weight gain and average daily gains for the period from 9 months of age to slaughter and from 7 months of age to slaughter are shown in table 12. Weaning age treatment had no effect (P>.60) on any of the traits listed in the table. Average daily gain was 1.04 vs 1.10 kg from 9 months of age to slaughter and 1.06 vs 1.04 kg from

TABLE 12. LEAST SQUARES ESTIMATES ± STANDARD ERRORS AND PROBABILITY VALUES (P) FOR WEIGHT GAIN AND AVERAGE DAILY GAIN FROM 9 MONTHS OF AGE TO SLAUGHTER AND FROM 7 MONTHS OF AGE TO SLAUGHTER

Source of variation	Final weight, kg	Total gain from 9 months to slaughter, kg	ADG from 9 months to slaughter, kg	Total gain from 7 months to slaughter, kg	ADG from 7 months to slaughter, kg
Weaning age					
7 months	459 ± 6.6	106 ± 5.4	1.04 ± .10	168 ± 5.2	1.06 ± .03
9 months	465 ± 6.9	110 ± 5.6	1.10 ± .10	168 ± 5.3	1.04 ± .03
P	.5490	.6303	.6594	.9370	.7525
Breed of sire					
Brahman	479 ± 7.2	109 ± 5.8	1.19 ± .10	171 ± 5.6	1.09 ± .02
Romana Red	445 ± 6.3	107 ± 5.2	.95 ± .10	165 ± 4.9	1.01 ± .03
P	.0004	.8036	.1059	.3976	.0208
Breed of dam					
Angus	421 ± 8.0	80 ± 6.5	.90 ± .12	142 ± 6.3	1.01 ± .03
SA[a]	503 ± 6.1	135 ± 4.9	1.24 ± .09	194 ± 4.7	1.10 ± .02
P	.0001	.0001	.0340	.0001	.0530
Year					
1983	458 ± 6.5	114 ± 5.3	.93 ± .10	166 ± 5.1	.94 ± .03
1984	466 ± 7.0	101 ± 5.7	1.22 ± .11	170 ± 5.5	1.17 ± .03
P	.4491	.0837	.0483	.5873	.0001

[a] Brown Swiss x Angus reciprocal F_1 and F_2 crossbreds.

7 months of age to slaughter for the early and late weaned groups, respectively.

In the period from 9 months of age to slaughter, Brahman-sired calves tended (P<.1059) to have a higher average daily gain than those sired by Romana Red bulls. When considering the period from 7 months of age to slaughter, the difference in average daily gain between Brahman- and Romana Red-sired steers increased (P<.0208). These results are similar to those reported by Robinson (1984). She also found no significant difference in weight gain and average daily gain between Brahman- and Romana Red-sired calves when both were fed to about 1 cm of outside fat thickness. Breed of dam significantly affected weight gain and average daily gain in both periods (table 12). Steers out of Brown Swiss x Angus crossbred dams gained more total weight (P<.0001) than those from Angus dams in both periods. This was because steers from the Brown Swiss x Angus crossbred dams were larger framed and had more potential for growth. Table 12 shows that steers out of Brown Swiss x Angus dams gained more per day (P<.0530) than those out of Angus dams for both periods, 1.24 vs .90 kg for the period from 9 months of age to slaughter, and 1.10 vs 1.01 kg for the period from 7 months of age to slaughter. These results are similar to those reported by Robinson (1984). In an experiment using the same breeds of dam and sire she also found that calves out of Brown Swiss x Angus dams gained more (P<.001) and required more days on feed

($P<.005$) to reach 1 cm fat thickness than those out of Angus dams. In her experiment, however, average daily gain was not affected ($P>.31$) by breed of dam. The feedlot performance of the steers from these two breed groups of dam are in accordance with the preweaning data presented in table 2. Steers out of Brown Swiss x Angus crossbred dams were significantly heavier at 5 and 7 months of age. Prichard (1983) also found that calves from the Brown Swiss x Angus dams had larger frame scores and were heavier at each weight period during the preweaning phase than were those out of Angus dams. The Brown Swiss is a larger breed than the Angus and the genetic superiority for size of the Brown Swiss x Angus dams was evidently transmitted to their progeny. Similar results were observed by Hargrove et al. (1983a), when comparing calves from Angus, Brown Swiss, and F_1 Angus x Brown Swiss dams. Crockett et al. (1979) reported that both initial and final weights were affected by breed of dam.

Year effects were significant for average daily gain in the periods from 9 months of age to slaughter and from 7 months of age to slaughter. Average daily gains were higher ($P<.0001$) in 1984, probably due to a higher energy content of the ration used. Steers reached 1 cm fat thickness an average of 31 days earlier ($P<.0001$) in 1984 than in 1983 (table 13).

Concentrate consumption, average gain, and feed efficiency from 9 months of age to slaughter and from 7

TABLE 13. LEAST SQUARES ESTIMATES ± STANDARD ERRORS AND PROBABILITY VALUES (P) FOR SLAUGHTER TRAITS

Source of variation	Slaughter weight, kg	Slaughter age	Slaughter weight/day of age, kg	GIT[a] fill, kg	Empty body weight, kg	Dressing[b] %	Hide weight, kg
Weaning age							
7 months	440 ± 6.3	372 ± 4.3	1.23 ± 0.01	22 ± 0.8	419 ± 6.1	63.7 ± 0.3	37 ± 0.6
9 months	445 ± 6.6	374 ± 4.4	1.23 ± 0.02	24 ± 0.8	412 ± 6.3	63.0 ± 0.3	37 ± 0.7
P	.6272	.6626	.8877	.0358	.8687	.1331	.7108
Breed of sire							
Brahman	457 ± 6.8	376 ± 4.6	1.26 ± 0.02	25 ± 0.9	432 ± 6.8	63.3 ± 0.3	40 ± .70
Romana Red	428 ± 6.1	371 ± 4.1	1.21 ± 0.01	22 ± 0.8	407 ± 5.8	63.4 ± 0.3	35 ± .60
P	.0028	.3977	.0216	.0024	.0075	.7082	.0001
Breed of dam							
Angus	403 ± 7.7	356 ± 5.2	1.17 ± 0.02	21 ± 1.0	383 ± 75	62.7 ± 0.4	35 ± .79
SA[c]	482 ± 5.8	390 ± 3.9	1.29 ± 0.01	25 ± 0.8	457 ± 56	63.9 ± 0.3	40 ± .58
P	.0001	.0001	.0001	.0026	.0001	.0191	.0001
Year							
1983	443 ± 6.2	389 ± 4.2	1.19 ± 0.02	24 ± 0.9	420 ± 6.7	63.1 ± 0.3	37 ± .63
1984	442 ± 6.7	358 ± 4.5	1.28 ± 0.03	22 ± 0.9	420 ± 11.4	63.5 ± 0.4	37 ± .72
P	.9468	.0001	.0001	.1876	.9521	.4076	.7176

[a] Gastrointestinal tract.

[b] Breed of dam x weaning age group interactions affected dressing percentage ($P < .0458$).

[c] Brown Swiss x Angus reciprocal F_1 and F_2 crossbreds.

months of age to slaughter are presented in tables 6 and 7. Consumption per steer was greater in 1983 than in 1984. This may have been caused by switching to a different ration the latter year. The ration fed in 1984 had a higher energy and dry matter content than the one fed in 1983 (3.75 vs 3.15 ME/kg and 76 vs 73% dry matter, respectively). Changing the feedlot ration improved the feed efficiency considerably (10.3 vs 15.1 for the early weaned group and 11.6 vs 13.4 for the late weaned group). These values are higher than those reported by Robinson (1984). She reported an average feed efficiency value of 9.25, with the same breeds and using the same feedlot ration as used in the first year of this study. These feed efficiency values are relatively high when compared to those reported from other feedlot studies. Cesar (1984), Drouillard (unpublished data), and Lopes (1986), who used a diet similar to that used in 1984, reported feed efficiency values between 5 and 7 kg feed per kg of gain for Hereford and Hereford crossbred steers. Concentrate consumption and weight gains were averaged over years (table 7). In the period from 9 months of age to slaughter, the early- and late-weaned group consumed about equal amounts of concentrate. However, in the period from 7 months of age to slaughter, the late-weaned group consumed about 168 kg less than the early-weaned group. The difference was a result of less concentrate consumption by the late-weaned group while they were still with their dams. Feed efficiency values were about equal for the early and late weaned groups in both periods (13.3 vs 13.0, from 9 months of age to slaughter, and 11.3 vs 10.2 from 7 months of age to slaughter).

Slaughter Traits

Least squares estimates, standard errors, and probability values for slaughter traits are presented in table 13. Weaning age treatment had no significant effect on slaughter weight, age at slaughter, slaughter weight per day of age, empty body weight, dressing percentage, or hide weight, but did affect (P<.0358) gastrointestional tract (GIT) fill. Age at slaughter was about equal for both weaning age groups; therefore, the late-weaned group required less time in the feedlot to reach 1 cm outside fat thickness than did the early-weaned group. Breed of sire affected (P<.003) slaughter weight, slaughter weight per day of age, GIT fill, empty body weight, and hide weight, but did not affect (P>.39) slaughter age or dressing percentage. Brahman-sired steers were 29 kg heavier (P<.003) at slaughter than those sired by Romana Red bulls. These results differ from those reported by Robinson (1984). She reported no difference (P>.97) in slaughter weight between Brahman and Romana Red-sired steers. In both experiments attempts were made to slaughter steers when they reached 1 cm outside fat thickness. Robinson (1984) further reported a significant breed of sire effect on days on feed, a result which differs from that found by this author. Brahman-sired steers had more (P<.0024) GIT fill and a heavier (P<.0001) hide weight than those sired by Romana Red bulls. This would appear to be contradictory to the higher dressing percentage found for Brahman-sired steers as compared to those sired by Romana Red. However, when weight of hide and GIT fill for the two groups are expressed as a percentage of slaughter weight, the two values differ by only .9%. Breed of dam significantly affected all slaughter traits measured. Steers out of Brown Swiss x Angus crossbred dams were 79 kg heavier (P<.0001) at slaughter, .12 kg heavier in weight (P<.0001) per day of age, and 34 days older (P<.0001) at slaughter than those out of Angus dams. The data further showed that, compared to steers out of Angus dams, the steers out of Brown Swiss x Angus dams had more GIT fill (P<.0026), a heavier empty body weight (P<.0001), a higher dressing percentage (P<.02), and heavier hide weights (P<.0001). When comparing dressing percentages of beef and dairy steers, varying results have been reported. Branaman et al. (1962), Wellington (1971), and Koch et al. (1982) showed dairy breeds to dress lower than beef breeds, while Cole et al. (1963), Judge et al. (1965), and Urick et al. (1974) showed just the opposite. A possible explanation of why the crossbred steers in this study, with a 25% Brown Swiss breeding, had a higher dressing percentage than those with no dairy breeding is that the Brown Swiss breed is a relatively large dairy breed when compared to other dairy breeds. Steers out of F_1 Brown Swiss x Angus dams were heavier at slaughter and heavy steers usually dress higher than light steers (Henderson, 1969). The fact that GIT fill was higher for steers out of Brown Swiss x Angus dams agrees with results reported by Robinson (1983). Henderson (1969) also found dairy breeds (Holsteins) to have a larger gastrointestinal tract relative to body weight than beef steers.

Year effect was significant for slaughter weight per day of age, GIT fill, and dressing percentage, but not for slaughter weight, empty body weight, or hide weight. Steers reached 1 cm of fat thickness 31 days earlier in 1984 than in 1983. This was probably a result of using different feedlot rations in the two years.

Carcass Characteristics

Yield Grade and Component Factors

Least squares estimates, standard errors, and probability values for USDA yield grade and component factors are presented in table 14. Weaning age treatment had no significant effect on hot carcass weight, fat over the ribeye, ribeye area, ribeye area per 100 kg hot carcass weight (REA/cwt), or USDA yield grade, but did affect ($P<.02$) percent kidney, pelvic, and heart fat (KPH). The early-weaned group deposited more ($P<.02$) KPH than the late-weaned group. This was probably due to the fact that the

TABLE 14. LEAST SQUARES ESTIMATES ± STANDARD ERRORS AND PROBABILITY VALUES (P) FOR USDA YIELD GRADE AND COMPONENT FACTORS

Source of variation	Hot carcass weight, kg[a]	Fat over ribeye cm^2 [b]	Ribeye area cm^2 [c]	Ribeye area/ 100 kg hot carcass wt, cm^2	Kidney, heart and pelvic fat, %[cd]	USDA yield grade[e]
Weaning age						
7 months	281 ± 4.1	.92 ± .03	75 ± .96	27 ± .43	2.5 ± .08	2.5 ± .05
9 months	281 ± 4.1	.91 ± .03	75 ± .99	27 ± .43	2.2 ± .08	2.5 ± .05
P	.9878	.7455	.5423	.5529	.0143	.6923
Breed of sire						
Brahman	290 ± 4.8	.98 ± .03	75 ± 1.03	26 ± .46	2.0 ± .09	2.5 ± .06
Romana Red	272 ± 4.0	.85 ± .03	75 ± .91	28 ± .39	2.6 ± .07	2.5 ± .05
P	.0054	.0015	.9919	.0056	.0001	.4568
Breed of dam						
Angus	254 ± 5.3	.97 ± .03	73 ± 1.16	29 ± .52	2.3 ± .10	2.4 ± .08
SA[f]	308 ± 3.8	.85 ± .03	77 ± .88	25 ± .37	2.4 ± .08	2.6 ± .07
P	.0001	.0044	.0121	.0001	.4937	.0102
Year						
1983	280 ± 4.2	.82 ± .03	74 ± .94	26 ± .40	2.1 ± .09	2.5 ± .06
1984	282 ± 4.8	1.01 ± .03	76 ± 1.00	27 ± .47	2.5 ± .10	2.5 ± .07
P	.7316	.0001	.2421	.4724	.0129	.6428

[a] Breed of dam x weaning age group interactions affected hot carcass weight ($P < .0899$).

[b] Breed of sire x breed of dam x weaning age group interactions affected fat over ribeye ($P < .0170$).

[c] Breed of dam x weaning age group interactions affected ribeye area ($P < .0718$).

[d] Breed of sire x breed of dam x weaning age group interactions affected kidney, heart, and pelvic fat ($P < .0329$).

[e] Breed of sire x breed of dam interactions affected USDA yield grade ($P < .0384$).

[f] Brown Swiss x Angus reciprocal F_1 and F_2 crossbreds.

late-weaned group was on pasture longer and consumed less grain than the early-weaned group. These results are in accordance with those reported by Crouse et al. (1984). They found that forage fed heifers deposited a lower percentage of KPH than did grain fed heifers, when both were fed to a constant fat endpoint. Brahman and Romana Red-sired steers differed significantly in fat over the ribeye, REA/cwt, and percent KPH. Brahman-sired steers had more fat ($P<.0015$) over the ribeye at slaughter did than those sired by Romana Red bulls. This was, however, not a true breed of sire effect. Due to economic and practical reasons, some steers were slaughtered before they reached 1 cm of outside fat. A greater percentage of these animals was sired by Romana Red bulls and out of Brown Swiss x Angus dams, a breed combination that seemed to mature and fatten slower than the Brahman x Angus crosses. Although Brahman-sired steers were slaughtered with more fat over the ribeye, they still had less ($P<.0001$) KPH than those sired by Romana Red bulls.

Breed of dam significantly affected USDA yield grade and all component factors except percentage KPH. Steers out of Brown Swiss Angus dams had heavier ($P<.0001$) hot carcass weights and larger ($P<.0121$) ribeye areas than those from Angus dams. Steers out of Angus and Brown Swiss x Angus dams differed significantly in fat over the ribeye, but this was due to the fact that a number of steers were slaughtered before they reached 1 cm of fat thickness. The majority of these steers were sired by Romana Red bulls and out of Brown Swiss x Angus dams.

Year significantly affected fat over the ribeye and percentage KPH, but did not affect yield grade and the other component factors. Steers slaughtered in 1984 had more fat over the ribeye and a higher percentage of KPH than those slaughtered in 1983. This was partially due to the fact that it was necessary, due to economics, to terminate the feedlot phase in 1983 before all steers had reached 1 cm fat thickness.

The breed of dam by weaning age group interactions were significant for hot carcass weight and ribeye area ($P<.0899$ and $P<.0178$, respectively). Least squares estimates and standard errors for hot carcass weight by breed of dam and weaning age treatment are presented in table 15. Steers from Brown Swiss x Angus dams produced heavier carcasses than those out of Angus dams. This advantage was greater for the late-weaning group than for the early-weaned group. Table 16 shows least squares estimates and standard errors for ribeye area by breed of dam and weaning age treatment. This table shows the same trend as that described for hot carcass weight. Steers from Brown Swiss x Angus dams produced carcasses with larger ribeye area than those from Angus dams, with this advantage being greater for the late-weaned group.

TABLE 15. LEAST SQUARES ESTIMATES ± STANDARD ERRORS FOR HOT CARCASS WEIGHT BY BREED OF DAM AND WEANING AGE TREATMENT[a]

Weaning age treatment	Breed of dam	
	Angus	SA[b]
	----------- kg	------------
Early weaning	259	303
Late weaning	249	313

[a] Breed of dam x weaning age group interactions affected hot carcass weight ($P<.0899$).

[b] Brown Swiss x Angus reciprocal F_1 and F_2 crossbreds.

TABLE 16. LEAST SQUARES ESTIMATES ± STANDARD ERRORS FOR RIBEYE AREA BY BREED OF DAM AND WEANING AGE TREATMENT[a]

Weaning age treatment	Breed of dam	
	Angus	SA[b]
	cm^2	
Early weaning	74	75
Late weaning	72	79

[a] Breed of dam x weaning age group interactions affected ribeye area $(P<.0718)$.

[b] Brown Swiss x Angus reciprocal F_1 and F_2 crossbreds.

Quality Grade and Component Factors

Least squares estimates, standard errors, and probability values for USDA quality grade and component factors are presented in table 17. Weaning age treatment did not significantly affect quality grade, carcass maturity, marbling, or texture and firmness of lean, but did affect color of lean ($P<.03$) and fat ($P<.08$). Steers weaned at 9 months of age had slightly darker colored lean and fat than those weaned at 7 months of age. Considering that the late weaned group was on pasture 2 months longer than the early-weaned group and was in the feedlot less than 90 days, this might have been expected. The literature indicates that forage fed steers have darker colored lean and fat than grain fed steers (Crouse et al., 1984; Bidner et al., 1981). These differences were, however, small and of no economical importance because this difference did not affect quality grade. Both weaning age groups had a USDA quality grade of Low Good. Steers sired by Brahman and Romana Red-sired bulls did not differ significantly in color and firmness of lean, but did differ in USDA quality grade, marbling score, texture of lean, and color of fat ($P<.08$). Brahman-sired steers had significantly higher marbling scores and, as a result, a higher USDA quality grade than did the Romana Red-sired steers. These results are different from those reported by Robinson (1984). She found no difference in marbling score and USDA quality grade between Brahman and

TABLE 17. LEAST SQUARES ESTIMATES ± STANDARD ERRORS AND PROBABILITY VALUES (P) FOR USDA QUALITY GRADE AND COMPONENT FACTORS

Source of variation	Carcass maturity[a]	Marbling[b]	Lean color[c]	Lean texture[d]	Lean firmness[e]	Fat color[f]	Quality grade[g]
Weaning age							
7 months	150 ± 3.4	314 ± 8.8	3.2 ± .10	2.7 ± .08	2.7 ± .08	1.9 ± .06	13.1 ± .18
9 months	150 ± 3.5	313 ± 9.1	3.5 ± .10	2.8 ± .08	2.6 ± .08	2.0 ± .06	13.2 ± .19
P	.9768	.9468	.0280	.5188	.4010	.0710	.8943
Breed of sire							
Brahman	149 ± 3.8	326 ± 10.1	3.4 ± .12	2.9 ± .09	2.7 ± .08	1.9 ± .06	13.3 ± .25
Romana Red	151 ± 3.3	301 ± 8.9	3.2 ± .10	2.6 ± .08	2.5 ± .07	2.0 ± .06	13.0 ± .24
P	.6600	.0799	.2187	.0749	.1068	.0690	.0772
Breed of dam							
Angus	152 ± 4.3	309 ± 11.6	3.4 ± .13	2.6 ± .10	2.5 ± .09	2.0 ± .07	13.1 ± .28
SA[h]	147 ± 3.1	318 ± 8.5	3.3 ± .10	2.9 ± .08	2.8 ± .07	1.9 ± .06	13.2 ± .18
P	.3804	.5734	.7954	.0432	.0044	.1846	.9458
Year							
1983	155 ± 3.4	291 ± 10.4	3.8 ± .10	2.9 ± .08	2.4 ± .07	2.3 ± .06	12.9 ± .22
1984	145 ± 3.9	336 ± 11.5	2.9 ± .11	2.7 ± .09	2.9 ± .09	1.6 ± .07	13.4 ± .24
P	.0515	.0135	.0001	.1234	.0001	.0001	.0022

[a] Average maturity of bone and lean, 100-199 = A^0 to A^{99} maturity.

[b] 0-99 = devoid, 100-199 = practically devoid, 200-299 = traces, 300-399 = slight.

[c] 7 point scale where 2 = very light cherry red, 3 = light cherry red, and 4 = cherry red.

[d] 7 point scale where 2 = fine and 3 = moderately fine.

[e] 7 point scale where 2 = firm and 3 = moderately firm.

[f] Continuous 6 point scale where 1 = white and 6 = yellow, using fat color chips developed by Western Australian Department of Agriculture.

[g] 21 point scale where 12 = Standard, 13 = Low Good, and 14 = Good.

[h] Brown Swiss x Angus reciprocal F_1 and F_2 crossbreds.

Romana Red-sired steers. Breed of dam did not significantly affect USDA quality grade or component factors except texture and firmness of lean. Steers out of Brown Swiss x Angus dams had a coarser (P<.05) and firmer (P<.005) lean than those out of Angus dams. Year effect was significant for USDA quality grade and all of the component factors except texture of lean. A possible explanation why carcass maturity was higher in 1983 is that steers reached 1 cm of fat thickness 31 days later than steers in 1984 (table 13). Marbling score and the closely related quality grade were higher in 1984 than in 1983. This was not surprising since steers in 1984 were fatter at slaughter than those in 1983 (table 14).

Carcass Composition

Data on estimated carcass composition are presented in table 18. Carcasses of steers weaned at 7 months of age had more (P<.10) separable fat than carcasses of steers weaned at 9 months. There was no significant difference in percentage of separable lean and bone between the two weaning age groups, although percent separable bone tended (P<.1167) to be less in steers weaned at 7 months of age. Carcasses of Brahman- and Romana Red-sired steers did not differ (P>.10) in separable fat, lean, or bone. These results do not agree with those reported by Robinson (1984). She found that Romana Red-sired steers produced carcasses that had more (P<.0001) separable fat and less (P<.02)

TABLE 18. LEAST SQUARES ESTIMATES ± STANDARD ERRORS AND PROBABILITY VALUES (P) FOR ESTIMATED CARCASS COMPOSITION

Source of variation	Estimated carcass composition[a]		
	Separable fat, %	Separable lean, %[b]	Separable bone, %
Weaning age			
7 months	29.1 ± .40	55.2 ± .36	16.4 ± .17
9 months	28.1 ± .42	55.6 ± .38	16.8 ± .17
P	.0957	.4168	.1167
Breed of sire			
Brahman	28.9 ± .43	55.0 ± .39	16.8 ± .18
Romana Red	28.4 ± .39	55.8 ± .35	16.5 ± .16
P	.4222	.1093	.2832
Breed of dam			
Angus	29.3 ± .49	55.4 ± .44	16.2 ± .20
SA[c]	28.0 ± .37	55.4 ± .33	17.1 ± .16
P	.0499	.9327	.0019
Year			
1983	27.8 ± .39	56.0 ± .35	16.8 ± .17
1984	29.4 ± .43	54.7 ± .38	16.5 ± .18
P	.0057	.0182	.2717

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[a] Predicted using equations developed by Hankins and Howe (1946).

[b] Breed of sire x breed of dam interactions affected separable lean ($P<.0521$).

[c] Brown Swiss x Angus reciprocal F_1 and F_2 crossbreds.

separable lean than those of the Brahman-sired steers. Carcasses of steers from Brown Swiss x Angus dams contained less (P<.04) separable fat and more (P<.002) separable bone than carcasses of steers from Angus dams. There was no difference (P>.94) in percentage of separable lean between the two breed groups of dam. The carcasses from the 1984 steers were fatter (P<.005) and had less separable lean (P<.019), but did not differ (P>.27) in percent separable bone from those in 1983.

Palatability Attributes

Least squares estimates, standard errors, and probability values for palatability attributes of broiled loin steaks are presented in table 19. Steers weaned at 7 months of age had lower (P<.008) Warner-Bratzler Shear (WBS) force values than those weaned at 9 months of age. This may have been a result of difference in amount of concentrate consumed by the two groups. The late weaned group consumed less concentrate and was in the feedlot for a shorter period of time than the early weaned group. There are conflicting reports in the literature on the effects of grain feeding on WBS force values. When steers were fed to a constant slaughter weight, Bidner et al. (1981) found no difference in WBS force values between steaks from the grain-fed and the forage-fed groups. Similar results were reported by Crouse et al. (1984), who found WBS force values of steaks obtained from grass-fed heifers to be no different from

TABLE 19. LEAST SQUARES ESTIMATES ± STANDARD ERRORS AND PROBABILITY VALUES (P) FOR PALATABILITY ATTRIBUTES OF BROILED LONGISSIMUS MUSCLE

Source of variation	Warner-Bratzler shear force kg/1.27 cm core	Flavor intensity[a]	Juiciness[b]	Tenderness[c]	Connective tissue[d]
Weaning age					
7 months	6.3 ± .19	5.49 ± .06	5.23 ± .09	5.61 ± .11	5.62 ± .12
9 months	7.0 ± .19	5.63 ± .06	5.32 ± .09	5.38 ± .11	5.60 ± .12
P	.0080	.1013	.4796	.1580	.9234
Breed of sire					
Brahman	6.8 ± .20	5.54 ± .06	5.28 ± .09	5.47 ± .12	5.56 ± .13
Romana Red	6.5 ± .18	5.58 ± .05	5.27 ± .08	5.53 ± .11	5.67 ± .12
P	.3164	.6175	.9265	.7011	.5075
Breed of dam					
Angus	6.8 ± .23	5.56 ± .07	5.28 ± .10	5.46 ± .14	5.67 ± .15
SA[e]	6.6 ± .17	5.56 ± .05	5.26 ± .08	5.54 ± .10	5.55 ± .11
P	.4622	.9356	.9088	.6613	.5353
Year					
1983	7.9 ± .19	5.42 ± .05	5.31 ± .09	5.18 ± .11	5.34 ± .12
1984	5.4 ± .20	5.70 ± .05	5.24 ± .09	5.81 ± .12	5.88 ± .13
P	.0001	.0008	.5728	.0002	.0022

[a] 8 point scale where 1 = very bland and 8 = very intense.

[b] 8 point scale where 1 = very dry and 8 = very juicy.

[c] 8 point scale where 1 = very tough and 8 = very tender.

[d] 8 point scale where 1 = none and 8 = abundant.

[e] Brown Swiss x Angus reciprocal F_1 and F_2 crossbreds.

those obtained from grain-fed heifers. In this case heifers were fed to a constant 12th rib fat thickness of .8 cm. Bowling et al. (1977), on the other hand, reported that grain-finished beef had lower WBS force values than forage-finished beef of the same USDA quality grade.

There was no difference ($P>.10$) between early and late weaned groups, as measured by sensory panel, for flavor intensity, juiciness, tenderness, or connective tissue. There was, however, a tendency ($P<.1013$) for the sensory panel to find steaks from the 9-month group to have a more intense flavor than steaks from the 7-month weaning age group.

Breed of sire and of dam had no effect on any of the palatability attributes measured. Loin steaks from steers fed in 1983 had higher ($P<.0001$) WBS force values, but as measured by a sensory panel, were less tender ($P<.0002$), had less connective tissue ($P<.003$), and had a more intense flavor ($P<.0008$) than those fed in 1984.

Economic Comparison of the Early and Late Weaning Practices

A partial budget for an integrated 250 head, cow-calf operation which finishes about 100 head of steers per year is shown in table 20. Listed in the table are costs which a producer could expect if he decided to creep feed and finish his own steers, instead of selling noncreep-fed steers at weaning. Since these costs are only those associated with

TABLE 20. PARTIAL BUDGET FOR PRODUCTION COSTS OF AN INTEGRATED BEEF OPERATION FROM COW-CALF TO FINISHING

	Early weaned		Late weaned	
	---------- $ per head		-----------	
Creep feed[a]		54.60		54.60
Feedlot diet ingredients:[b]				
High moisture corn		187.35		180.12
Cottonseed hulls		24.66		23.71
Molasses		7.11		6.84
Protein pellets		24.03		23.10
Total feedlot cost	243.15		233.77	
Total feed cost	297.75		288.37	
Storage and mixing costs[c]		2.60		2.60
Feed handling[d]		3.48		3.48
Growth implants[e]		4.06		4.06
SpotOn[f]		.46		.46
TBZ dewormer[g]		2.15		2.15
Mineral mix[h]		3.33		2.96
Labor, working cattle[i]		.56		.56
TOTAL		314.39		304.64

Footnotes see Appendix A.

the creep feeding and finishing operation, they will be referred to as added costs and do not represent all cost associated with an integrated system. It was assumed that steers were put into the feedlot at weaning and full-fed to an estimated 1 cm fat thickness, which in this study was reached at an average age of 370 days. Steers were fed in existing dirt lots with covered feed bunks. These facilities were relatively old and no depreciation costs were considered for them in this study. Added costs are given for situations where steers are weaned at 7 months of age and where calves are weaned at 9 months of age. Care must be taken in interpreting the data in table 20. It is not a profit or loss statement, because all costs are not considered. The added costs were $314.39 and $304.64 per head for the early- and late-weaned groups, respectively. This is an advantage of $9.75 per head for the late-weaned group over the early-weaned group.

Figure 1 shows growth curves for the early- and late-weaned groups. Both groups lost weight at weaning, but finished at approximately the same slaughter weight. If slaughter steers sold for $1.20 per kg, the producer would receive $354.00 ($1.20 x 445) per head. After subtracting the added cost from this amount, the producer is left with $219.61 ($534.00 - $314.39) and $229.36 ($534.00 - $304.64) for the early- and late-weaned groups, respectively.

Another point to consider is the effect that a decreased calving percentage due to the late weaning has

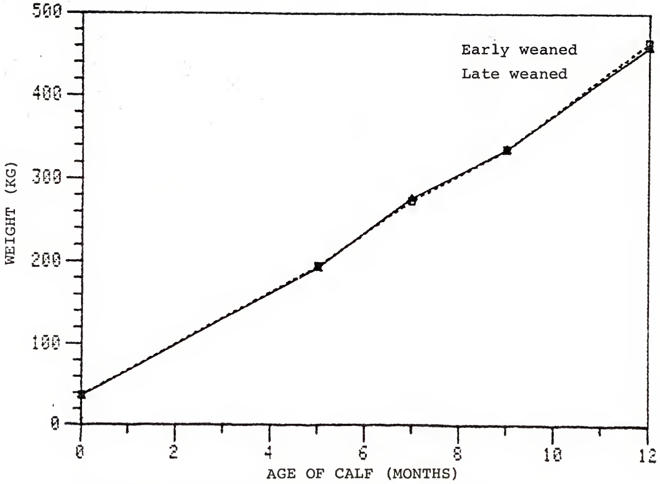

FIGURE 1. CALF GROWTH BY WEANING AGE GROUP

on the economic situation. Table 8 showed that late weaning decreased subsequent pregnancy rates by 8 percentage points (96 vs 88% for the early- and late-weaned groups, respectively). And even though this difference was not statistically different, it does have a considerable impact on the profitability of late weaning. Table 21 shows the difference in returns between an integrated system using early weaning and one using late weaning, when pregnancy rates are considered. The calculations in this table show that even though it costs about $10 less per head to produce slaughter steers using the late-weaning system as compared to the early-weaning system, the producer has a greater return ($898.88 more) from the early-weaning system because he weans an average of eight more steers per year. The calculations were done for a 100 head, brood-cow herd. From now on all calculations will be based on figures obtained from the early-weaned group.

To determine if finishing creep-fed steers is economical for the producer, this practice was compared with one where the producer sells noncreep-fed steers at weaning (feeder-stocker calves). In an experiment using the same breed combinations, Robinson et al. (1984) reported that the average adjusted 210-day weight of noncreep-fed steers was 247 kg. If medium frame feeder steers of this weight sold for $1.30 per kg, the producer would receive $321.10 (247 x $1.30) per head, which is $101.49 ($321.10 - $219.61) more per head than when he finished his own creep-fed steers.

TABLE 21. RETURNS FOR AN INTEGRATED SYSTEM COMPARING EARLY VERSUS LATE WEANING PRACTICES

Item	Weaning age	
	Early	Late
Number of steers[a]	96	88
Cost per head, $	314.39	304.64
Live weight sold, kg	445	445
Market value, $[b]	534	534
Return per head, $[c]	219.61	229.36
Total return, $[d]	2108.56	20183.68

[a] Based on a 100 brood cow herd.

[b] Market value = 445 kg x $1.20 = $534.

[c] Return per head = market value - cost per head.

[d] Total return = number of steers x return per head.

Whether the integrated system is more or less profitable than selling weaned calves will depend to a large part on the price of feeder-stocker calves versus slaughter steers. With price of feeder steers remaining at $1.30/kg and the price of slaughter steers increasing by 15% ($1.38/kg), the returns of two systems would be about equal. But if price of slaughter steers increased by 20% ($1.44/kg) the situation changes, and the producers selling slaughter beef earns about $5.00 per head more than the producer selling feeder-stocker calves. Price fluctuations of this magnitude are very common. Between the time the data were collected and this dissertation written, the price of slaughter beef increased about 21% while the price of feeder-stocker calves increased about 3%.

With the practice of finishing his own creep-fed steers, the producer gets 198 kg (445 - 247 kg) of gain for his added cost, resulting in a cost of gain of $1.58 ($314.02/198) and $1.54 ($305.01/198) per kg for the early- and late-weaned groups, respectively. The major contributor to this high cost of gain was the total feed cost, which represented 95% of the total added cost for both the early- and late-weaned groups. The feed costs can be divided into the cost of creep feed that was fed in the period from 5 to 7 months of age and the cost of the feedlot ration that was fed in the period from 7 months of age to slaughter ($54.60 vs $243.15, respectively). Steers gained 81 kg from 5 to 7 months of age (table 3). This resulted in a creep feed cost of gain of \$.67 (\$54.60/81) per kg for the preweaning period. From 7 months of age to slaughter, gains were 168 and 157 kg for the early- and late-weaned groups, respectively (table 12), resulting in cost of gain of \$1.44/kg (\$243.15/168) and \$1.49/kg (\$233.77/157) for the two weaning age groups. Unless feedlot diet costs can be reduced, the cost of gain will remain too high for the production of fed beef in Florida.

SUMMARY AND CONCLUSIONS

One hundred and twenty-five steers sired by Brahman or Romana Red bulls and from Angus or Angus x Brown Swiss F_1 and F_2 crossbred (SA) dams were used to study the effects of weaning age (7 vs 9 months) on preweaning and postweaning performance, slaughter traits, and carcass characteristics. Steers were implanted with 36 mg Ralgro^R at about 60 and 150 days of age and started on creep feed at an average age of 5 months. After weaning, steers were fed to an estimated fat thickness of 1 cm, slaughtered, and carcass data collected.

Brahman-sired calves weighed 4 kg more ($P<.0001$) at birth and 24 kg more ($P<.0001$) at 5 months of age than those sired by Romana Red bulls. Calves out of SA dams weighed 4 kg more ($P<.0003$) at birth and 17 kg more ($P<.0013$) at 5 months of age than those out of Angus dams. Creep consumption from 5 to 7 months of age was 3.00 and 3.55 kg per calf for 1983 and 1984, respectively. Weaning age had no significant effect on 7- and 9-month weights, condition scores, or adjusted 205- and 265-day weights. Brahman-sired steers were heavier ($P<.0001$) at 7 and 9 months of age, and 10 days older at each weaning date ($P<.0005$) than those sired by Romana Red bulls. When weights were adjusted to age constant bases of 205 and 265 days, the weight difference decreased but remained significant. Condition scores at 7 and 9 months of age were significantly higher for Romana Red-sired steers than those sired by Brahman bulls. Steers out of Angus dams had higher (P<.0001) condition scores than those out of SA dams, at both the early and the late weaning dates. Weaning age group, breed of sire, and breed of dam did not affect (P>.1672) weight gain or average daily gain from 7 to 9 months of age. The early- and late-weaned groups gained 62 and 58 kg, respectively, during this 2-month period. Weaning age and breed group of dam affected (P<.0085) condition score change between the early and late weaning dates, but breed of sire did not (P>.9469). The early-weaned group increased more in condition than those weaned 2 months later. Late-weaned steers consumed an average of 180 kg less of the diet per steer than the early-weaned steers, from 7 to 9 months of age.

The dams whose calves were weaned at 9 months of age were lighter (P<.05) (451 vs 470 kg) and thinner (P<.001) (5.9 vs 6.5) at the late weaning date than dams those whose calves were weaned 2 months earlier. Dams whose calves were weaned early gained an average of 16 kg, while dams whose calves were not weaned until 2 months later lost an average of 1 kg in the period between early and late weaning. The SA dams were 37 and 34 kg heavier (P<.001) than the Angus dams at the early and late weaning dates, respectively. The overall change in weight was, however, not different (P>.40) for the two dam breeds. Body condition scores, on the other hand, were lower (P<.0001) for the SA dams than for the Angus dams at both the early and late weaning dates (6.0 vs 7.3 and 5.5 vs 6.9, respectively). However, the overall change in body condition between the early and late weaning dates was not different (P>.71) for the two breed groups of dams. Sire breed of calf did not affect (P>.52) condition score at the early weaning date, but did affect (P<.03) condition score at the late weaning date. Dams whose calves were sired by Romana Red bulls lost more condition (P<.05) between the early and late weaning dates than those whose calves were sired by Brahman bulls. There were significant breed of dam x sire breed of calf interactions for dam condition scores at the early and late weaning dates, and significant breed of dam x weaning age group interactions for dam condition score change between the early and late weaning dates.

Pregnancy rate in the subsequent year was not affected (P>.21) by weaning age treatment, dam breed, or sire breed of calf. There was a tendency, however, for the dams whose calves were late weaned to have a lower pregnancy rate than those whose calves were weaned 2 months earlier (88 vs 96%).

Weaning age treatment had no significant effect on weight gain and average daily gains (ADG) for the periods from 9 months of age to slaughter and from 7 months of age to slaughter. Brahman-sired steers outgained those sired by Romana Red bulls in both periods. Steers out of SA dams gained more (P<.0001) and had a higher average daily gain in both periods than those out of Angus dams.

Averaged over years, feed efficiency was about equal for the early- and late-weaned groups in both periods (13.3 vs 13.0, respectively, from 9 months of age to slaughter, and 11.3 vs 10.2, respectively, from 7 months of age to slaughter).

Weaning age treatment had no significant effect on slaughter weight per day of age, gastrointestinal tract (GIT) fill, empty body weight, dressing percentage, or hide weight. Brahman-sired steers were 29 kg heavier (P<.003) at slaughter, had more (P<.003) GIT fill, and heavier (P<.0001) hide weights than those sired by Romana Red bulls. Steers out of SA dams were 79 kg heavier (P<.0001) at slaughter, .12 kg heavier (P<.0001) per day of age, and 34 days older (P<.0001) at slaughter than those out of Angus dams. Steers out of SA dams also had more (P<.003) GIT fill, heavier (P<.0001) empty body weights, higher (P<.02) dressing percentage, and heavier (P<.0001) hide weights.

Weaning age treatment had no significant effect on hot carcass weight (HCW), fat over the ribeye, ribeye area, ribeye area per 100 kg hot carcass weight (REA/cwt), or USDA yield grade, but did affect (P<.02) percentage of kidney, pelvic and heart (KPH) fat. The late-weaned group had less KPH than those that were weaned 2 months earlier. Brahman-sired steers had heavier (P<.0054) HCW and more (P<.0056) REA/cwt than those sired by Romana Red bulls.

However, breed of sire did not affect (P<.99) ribeye area or USDA yield grade (P<.46). Breed of dam significantly affected USDA yield grade and all component factors except percentage of KPH fat. Steers out of SA dams had heavier HCW (P<.0001), more ribeye area (P<.0121), less REA/cwt (P<.0001), and higher USDA yield grades (P<.0102).

Weaning age treatment did not significantly affect quality grade, carcass maturity, marbling, or texture and firmness of lean, but did significantly affect color of lean and fat. The late-weaned group had darker lean and fat than the early-weaned group. Brahman- and Romama Red-sired steers did not differ significantly in carcass maturity or color and firmness of lean, but did differ in USDA quality grade, marbling score, texture of lean, and color of fat (P<.08). Brahman-sired steers had significantly higher marbling scores and, as a result, higher USDA quality grades than did the Romana Red-sired steers. Breed of dam did not significantly affect USDA quality grade or the component factors, except for texture and firmness of lean. Steers out of SA dams had coarser (P<.05) and firmer (P<.005) lean than those out of Angus dams.

Carcasses of steers weaned at 7 months of age had more (P<.10) separable fat than carcasses of steers weaned 2 months later, but did not differ in percentage of separable lean and bone. Brahman- and Romana Red-sired steers did not differ (P>.10) in carcass separable fat, lean, or bone. Carcasses of steers from SA dams contained less separable fat (P<.04) and more separable bone (P<.002) than carcasses of steers from Angus dams. There was no difference (P>.94) in percentage of separable lean between the two breed groups of dam. Steers weaned at 7 months of age had lower (P<.008) Warner-Bratzler Shear force values (WBS) than those weaned at 9 months of age. There was no difference (P>.10) between weaning groups, as measured by sensory panel, for flavor intensity, juiciness, tenderness, and connective tissue. Breed of sire and breed of dam had no significant effect on WBS, flavor intensity, juiciness, tenderness, or connective tissue.

Based on results of this study, it can be concluded that

1) under the conditions of this study, the Brahman breed was superior to the Romana Red breed for crossbreeding with *Bos Taurus* cattle;
2) in an integrated beef system, where steers are creep-fed and finished for slaughter, late weaning may be more economical than early weaning; and
3) under the conditions present at the time of this study and the economic data considered, it may not be economically feasible to creep feed late wean, and finish cattle in an integrated beef system in Florida.

APPENDIX A
FOOTNOTES FOR TABLE 20

[a] Creep feed was fed to the calves from 5 to 7 months of age. Steers consumed an average of 195 kg per head at $.28/kg.

[b] After 7 months of age, steers were fed a feedlot diet consisting of 79% high moisture corn, 12% cottonseed hulls, 5% molasses, and 4% of a 52% crude protein commercial pellet. This diet was used only the second year of the experiment, and the data shown in table 18 reflect only those from the second year. Consumption per head averaged 1581 and 1520 kg for the early- and late-weaned groups, respectively. The prices for feed ingredients used were $.15/kg for high moisture corn, $.13/kg for cottonseed hulls, $.09/kg for molasses, and $.38/kg for commercial protein pellets with 52% crude protein. Cost of feed ingredients for the early-weaned group was calculated as follows; .79 x 1581 x .15 = $187.35 for high moisture corn, .12 x 1581 x .13 = $24.66 for cottonseed hulls, .05 x 1581 x .09 = $7.11 for molasses, and .04 x 1581 x .38 = $24.03 for the commercial protein pellets. Costs per feed ingredient for the late weaned group was calculated as follows; .79 x 1520 x .15 = $180.12 for high moisture corn, .12 x 1520 x .13 = $23.71 for cottonseed hulls, .05 x 1520 x .09 = $6.84 for molasses, and .04 x 1520 x .38 = $23.10 for the commercial protein pellet. The cost per kg of feedlot diet used in this study was $.15.

[c] A small operator must have considerable storage to allow the flexibility of buying in bulk. Storage and mixing costs were calculated as follows; 5000 bu. galvanized steel bin + augur for $5000, 500 gal molasses tank for $500, and a 500 lb tractor-drawn, batch-type mixer-feeder at $1000. This comes to a total of $6500. Assume that this equipment is used 40% of the time for the finishing operation and is depreciated over a 10-year period ($6500 x .40 = $2600 ÷ 10 = $260/yr). We feed 100 head of steers. This cost comes to $2.60 per head.

[d] It was assumed that, in the period from 5 to 7 months of age, steers were creep fed from self-feeders which were refilled twice a week. It takes about 1 hour for one man to put out feed. This comes to 2 hours a week for 8 weeks at $3.50 per hour. The cost for creep feeding in this period comes to (2 x 8 x $3.50)/100 = $.56 per head.

For the late-weaned group, there is an extra 8-week period (from 7 to 9 months of age) in which the steers are creep fed. The feed fed in this period had a higher moisture content, spoiled easier, and had to be put out fresh every two days. Over a 60-day period the cost per head came to (30 x \$3.50)/100 = \$1.05. Feedlot steers were fed every day. It took one man about one-half hour to put out feed. The early-weaned group was in the feedlot for an average of 167 days and the late-weaned group for 107 days. Feed handling costs per steer while in the feedlot came to (167 x .5 x \$3.50)/100 = \$2.92 and (107 x .5 x \$3.50)/100 = \$1.87 for the early- and late-weaned groups, respectively. Feed handling costs for the total period were \$.56 + \$2.92 = \$3.48 and \$.56 + \$1.05 + \$1.87 = \$3.48 for the early- and late-weaned groups, respectively.

[e] Each steer was implanted twice preweaning with Ralgro at \$1.04 a dose and twice postweaning with Synovex-S at \$.99 a dose. (2 x \$1.04) + (2 x \$.99) = \$4.06/steer.

[f] Spoton was purchased at \$17.95 per pint and 39 animals weighing between 223 and 335 kg were treated with one pint, or \$17.95/39 = \$.46/steer.

[g] TBZ dewormer was purchased at \$13.95 a tube. There were an average of 6.5 doses per tube, thus, \$13.95/6.5 = \$2.15/steer.

[h] Calves consumed about .02 kg per day of mineral mix from 5 to 7 months of age for a total of 1.2 kg (60 x .02) of the mix for this period. After 7 months of age the early-weaned group consumed an average of .05 kg per day in the feedlot for 167 days. The late-weaned group consumed about .07 kg per day while on pasture from 7 to 9 months of age (60 days) and an average of .05 kg when put in the feedlot (107 days). If cost per kg of mineral mix was \$.31 than cost of mineral mix was (1.2 + 167 x .05) x .31 = \$2.59/head for the early-weaned group and (1.2 + (60 x .07) + (107 x .05)) x .31 = \$3.33/head for the late-weaned group.

[i] Steers were worked five times from the time they were 5 months of age until slaughter. With four men working the steers, it took an average of 4 hours to weigh and implant 100 head. If workers were paid \$3.50 per hour the cost per head would be (4 x 4 x \$3.50)/100 = \$.56.

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I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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